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NEW HAMPSHIRE AGRICULTURE.

# THIRTEENTH ANNUAL REPORT

OF THE

# N. H. BOARD OF AGRICULTURE

FOR THE YEAR ENDING

MAY 1, 1884.

BY JAMES O. ADAMS, SECRETARY.

CONCORD:
PARSONS B. COGSWELL, PUBLIC PRINTER.
1884.

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# BOARD OF AGRICULTURE.

ORGANIZED AUGUST, 1870.

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MEMBERS FOR 1883-'84.

MOSES HUMPHREY, Concord, *Chairman.*
JAMES O. ADAMS, Manchester, *Secretary.*
W. H. H. MASON, Moultonborough.
HIRAM PARKER, Lempster.
GEORGE K. HARVEY, Surry.
WILLIAM H. HILLS, Plaistow.
ALBERT DEMERITTE, Durham.
DAVID H. GOODELL, Antrim.
SIDNEY B. WHITTEMORE, Colebrook.
CHARLES W. HACKETT, Belmont.
JOHN E. CARR, North Haverhill.

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# STANDING COMMITTEES.

The Secretary is *ex-officio* a member of each committee.

*Finance*—Humphrey and Parker.

*Experimental Work*—Hackett and Hills.

*Farm Machinery*—DeMeritte and Goodell.

*Hygiene and Disease*—Mason and Hackett.

*Horses*—Whittemore and Humphrey.

*Neat Cattle*—Goodell and Carr.

*Sheep, Swine, and Poultry*—Harvey and Mason.

*The Dairy*—Parker and DeMeritte.

*Fruits and Vegetables*—Hills and Harvey.

*Miscellaneous Matters*—Carr and Whittemore.

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ROOMS OF THE BOARD OF AGRICULTURE,

CONCORD, MAY 1, 1884.

*To the Governor:*

The Thirteenth Annual Report of the Board of Agriculture, prepared by the Secretary, is hereby submitted in behalf of the board in accordance with the provision of the statute.

JAMES O. ADAMS, *Secretary.*

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# NEW HAMPSHIRE AGRICULTURE.

## MEETINGS OF THE BOARD.

During the year there has been but a single meeting of the board for the transaction of business. This was the regular annual session, and was held at Weirs, August the 30th. There were present Chairman Humphrey, Secretary Adams, and Messrs. Mason, Parker, Carr, Whittemore, and Goodell. An hour was spent in listening to reports for the year past, and in discussing plans for the future. It was voted that business matters be referred to the appropriate committees, who were authorized to take final action; but in cases of disagreement and of great importance, the secretary was instructed to call special meetings of the board.

The board, on invitation, met with the Patrons of Husbandry, and engaged in the exercises of the day, Messrs. Humphrey, Adams, and Mason making brief addresses. At the close of the public session the board adjourned to meet at the call of the secretary.

Mr. Joseph B. Walker, of Concord, who has always manifested a lively interest in the board, on invitation met with the members and participated in the exercises.

Formerly it was the practice of nearly all the members of the board to attend the meetings, even though they did not take part in the discussions. But recently the secretary and the member from the county in which a meeting is held are expected to take charge of the discussions in small towns, but are assisted by additional force in large places, and when more than one or two sessions are held. Occasionally gentlemen outside of the board, and sometimes ladies, accompany the members, and read papers and engage in the discussions; and now and

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then gentlemen from abroad have been invited to address the meeting, the expense being paid by order of the board.

### MEETING IN SANDWICH.

The first meeting for the season 1883–'84 was held at Centre Sandwich on Monday evening, October 29, and Tuesday the 30th. Present, Messrs. Humphrey, Adams, and Mason, accompanied by Mr. Joseph B. Walker, of Concord, as a volunteer.

Owing to a heavy rain on Monday, the attendance was limited to a small number residing near the village. Mr. Walker was the principal speaker, and his subject "Grass Growing." He regarded the grass crop of the state worth from six to seven millions of dollars, an amount double in value to the corn, wheat, and oat crop. He spoke from his own standpoint as a grass-grower on an alluvial, river farm near the Concord market, with level fields, free from stones, and with a fair soil. His rotation is corn, oats, and five years in grass; does not always go through the rotation, but once in five years plows eight and one half inches deep, in August or early September, to keep down the witch-grass for the time; puts on five cords of stable manure per acre, and plows it in three or four inches deep; sows herds-grass, a peck and a half to the acre, and red-top on moist lands; rolls the seed in, but does not harrow or brush it, and generally gets a good crop, or about two tons per acre, the next year.

On his oat land he plows and seeds as soon after harvesting as he is able.

On corn stubble he plows and sows the last of October, and gets a fair crop the first year.

This is the substance of Mr. Walker's talk for an hour. He laid great stress on the thorough pulverization of the soil and the even distribution of the manure. He was followed by remarks from Messrs. Locke, Moulton, Judge Hill, and others. Mr. Humphrey, of Concord, also made a brief talk on the point that the farmer enjoys more of true life than any other class of men.

On Tuesday morning Dr. Mason, member for Carroll county, presided, and introduced Mr. Humphrey, whose topic was "Stock Breeding." He spoke first of the condition of stock a quarter century ago. Then there was no special distinction: a cow was

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a cow, and a horse a horse. But an improvement took place, first by selection of breeding animals possessing the most desirable traits. A point to be regarded in its effect is, that only favorable impressions be made on the breeding female. Diseased animals should not be used for stock purposes, for they will transmit their defects to posterity. The same is true of the disposition of animals.

The speaker condemned the breeding of track horses with a view of making money. It is costly work and very risky business; very fascinating, but uncertain in its results. It is well to raise stout horses, fit for the horse-railroad and similar work. It is said 100,000 horses are used on the cars, and that 25,000 a year are used up. There will be a demand for such animals. The speaker advocated the use of pure-bred animals on one side, that we may be constantly improving the herd.

Mr. Walker stated that in our state we had only one animal to four acres of land. In Italy he found four animals to each acre. He argued that it is absolutely necessary to keep animals in order to keep up the fertility of our farms. Stock-growing is a complement of grass-growing: they go together. He then showed how to improve our native stock by introducing shorthorn stock to native cows, and continuing the practice for generations, until high grades are obtained, which are equal in profit to full bloods. Early maturity was urged, but close breeding condemned. The speaker thought it beyond our power to control the sex, but he gave authority on this point which tended to show that when the female is the more vigorous, males are the result, and the reverse is true when the male is the more passionate. An experiment proved that of eight cows the owner produced seven heifers and one bull, on this theory.

In the afternoon the subject of corn-growing was presented by Messrs. Humphrey, Walker, and others. The secretary followed with the ensilage question, and occupied the evening in a talk on the elements which constitute good farming.

### MEETING IN TUFTONBOROUGH.

The second meeting of the board in Carroll county was held October 31st at Melvin Village in Tuftonborough. This is a hilly and rocky town, but productive in farm crops, especially corn,

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grass, and wheat. The farmers are generally well-to-do, and many of them are free from debt, with a little ready cash.

The meeting was conducted by Dr. Mason, of Moultonborough, and Secretary Adams. The subject of corn-growing was presented, but in a different way from that at Sandwich. The points made were, that the farmer must grow the largest crop at the least cost. To do this he must first use land adapted to corn, leaving the moist lands for grass, and such crops as will thrive on moist soil. In the second place, plow and harrow thoroughly, as deep as circumstances warrant; third, secure the best seed, by selection and cultivation from year to year; fourth, plant with machines, if possible, the manure having been harrowed in, and a little phosphate put in the hill, and instead of using the hoe make use of the harrow and the cultivator, so far as practicable. When the corn is glazed, cut up and shock in the field to save the stalks from frost and storm. The fodder will be much better to feed out—worth half the price of hay—and the corn will be equally as good as when ripened on the hill. Corn may be grown at a cost of from thirty-three to fifty cents per bushel, and the soil be the better prepared for a succeeding crop. In feeding, it was urged that it be accompanied by clover hay, shorts, cotton-seed meal, or other substances containing flesh-making material.

In the evening Dr. Mason spoke of the needed care of animals, and gave a detailed account of the treatment of various diseases of animals. He was followed by the secretary, in outlining the methods pursued by the best farmers in the management of their farms and their stock. The attendance was large, and the meeting very spirited. Melvin Village is one of the localities which always give the board a welcome.

### MEETINGS IN COÖS COUNTY.

People have been accustomed to regard Coös county as of little importance in the industries of the state. It is a far-off, cold, and uncultivated region, in the eyes of central and southern New Hampshire. Woods and water, high hills and deep valleys, stones and stumps, have been considered its characteristic elements. Seven score miles from the ocean, with railroads only in its southern and eastern sections, cold winters and short

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summers, it has not long been looked upon as a desirable locality. So thought the Secretary up to a recent date, when he had an opportunity to explore its entire area. from Shelburne to Pittsburg on the lake, a distance of one hundred miles.

Since the year 1850, says a reporter of the *Union*, who accompanied the board, we have made visits to the county, and have recently completed our sixteenth excursion, an agricultural one, this time in company with members of the agricultural board.

Messrs. Goodell and Adams of the board, from this section of the state, accompanied by Mr. Gerrish of the *People and Patriot* and a representative of the *Union*, left Concord on the 19th of November, by way of the Boston, Concord & Montreal Railroad, for a week's canvass in the southern and eastern sections of the county. Mr. Whittemore, the Coös member, joined the party at Lancaster, and Mr. Carr, of Grafton county, came in on the "home stretch" at Whitefield.

On Monday evening the board divided. Mr. Goodell held a meeting at Northumberland, and was aided by Mr. Gerrish. The meeting was well attended, and manifested much interest. The leading topic was that of "Keeping up with the Times" in agriculture, as well as in the mechanic arts, trade, and other interests.

At Groveton, Messrs. Adams and Whittemore presented the subject of "Stock Improvement" to an interested audience, recommending the crossing of pure bred sires on selected dams from the common herds.

On the next day a live meeting was held at West Milan, and Mr. Adams discussed the methods of feeding most economically, using the right proportions of albuminoids and hydro-carbons. On the evening of the same day a meeting was held at Berlin Falls. This is a lumber town, in which the Berlin Company manufacture 50,000,000 feet yearly, and send to Portland and other cities. The town has a population of 1700, and is rapidly growing. The water-power is constant and abundant. New mills for pulp and paper are in process of construction. Here Mr. Daniel Greene has an artificial cranberry meadow of sixty acres, and reaps a great harvest. In Milan, near by, is a copper mine, which employs a large force of men, and appears to be yielding a good return. A lead mine is operated in Gorham,

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and some fine specimens have been found. Heavy machinery is running by steam, and twenty men are employed.

Gorham gave the board a fine audience, and Messrs. Whittemore, Adams, and Goodell all made wide-awake talks on the use of machinery and thorough tillage.

At Shelburne the whole party were invited to the thousand-acre farm of Judge Burbank, of Boston. An hour was spent in examining his herds of thoroughbreds—Holstein and Dutch, Short-horns, Swiss, Ayrshires, and Jerseys. He has the largest variety of registered stock in the state.

The next meeting was at Randolph, and proved a lively one, half the people of the town being out.

In the evening the party went to Jefferson Hill, twelve miles distant, and held one of the best meetings of the season. Mr. Goodell talked The West *vs.* The East, Mr. Whittemore on stock, and Mr. Adams on farm improvement. The session was held till a late hour, and was full of interest. This is a beautiful place, as hundreds of summer boarders know. The town has a fine soil, and produces splendid crops. The building of the railroad from Whitefield is a great convenience.

Whitefield is another lumber town, where 30,000,000 feet or more are yearly manufactured into boards, building material, firkins, sash, &c. It is a busy place, and is surrounded by good farms. The Hazens have the largest farm, and have the past year built a barn over two hundred feet long. They keep nearly a hundred horses and more oxen for lumbering purposes, and cut three hundred tons of hay. Here the board held two good meetings, attended by ladies as well as gentlemen.

Saturday found us on our way home, a full week having been busily and happily employed. We have found the farmers encouraged by good crops and fair prices. Hay, wheat, oats, and potatoes have been abundant; neat stock, horses, and sheep have done unusually well.

Mr. Gerrish, in the *People and Patriot*, gave the following condensed report of "A Week with the Board:"

Leaving Concord Monday morning, November 19, on the express train over the Boston, Concord & Montreal Railroad, we leave the Merrimack valley for the higher table lands, and very

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soon reach the lake region. The waters of Sanbornton bay, placid as a mirror, lay in our path, but making a *detour*, we passed rapidly on, by Laconia, Lake Village, Meredith, and Ashland, reaching Plymouth at one P. M., where we dined; after which we took the accommodation train and made slower progress north, arriving at Littleton about dark. The glove interest is the making of these two places, so far as cold weather enterprises are concerned, and summer boarding for warm weather. We did not stop long enough to get the figures at Littleton, where the business is brisk; but at Plymouth we were told by a manufacturer that the business amounted to $250,000 a year, furnishing employment for three thousand hands, many of whom, we suppose, are women and children, and probably in outlying districts, the population of the town being only about two thousand.

Meetings being announced for both Groveton and Northumberland, a division of forces was necessary, Councillor Goodell speaking very acceptably to a respectable audience, not in Northumberland on account of repairs to the hall on the New Hampshire side of the river, but on the Vermont side at Guildhall, his subject being "Progress," which was well received; while Secretary Adams with member Whittemore went on to Groveton, where a small meeting was held, Messrs. Adams and Whittemore speaking on new points in agriculture.

The falls on the Connecticut at Northumberland are sufficient for considerable business. At present it is lumber on the Vermont side, and shoe-pegs and strawboard on the New Hampshire side.

Taking the morning train for Groveton Junction, the "rear guard" embark on the Grand Trunk Railway, and are reinforced at Groveton by the captain and secretary, who arrive at Milan together, again to separate in order to have meetings at West Milan and arrange for the evening at Berlin Falls, the advance guard going by rail, and the reserve following by private conveyance after the afternoon meeting.

A successful meeting was held at Milan. Secretary Adams spoke for an hour on "What the best farmers do," and Mr. Gerrish, of Webster, on "Grade and thoroughbred stock." This meeting was not large, but it was quite a satisfactory one.

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The travelling not being good, or from some misunderstanding, there was not a large attendance of farmers from out the place at Berlin Falls Tuesday evening. A very fine new hall was well warmed and lighted, and Mr. Brown of the Berlin Falls Lumber Company was present, with some mechanics and villagers.

Berlin Falls is a smart and growing place. Large quantities of spruce lumber are floated down the Androscoggin to this point and manufactured—upward of 30,000,000 feet annually. This goes to market over the Grand Trunk Railway. The place claims 1700 inhabitants at present.

At the meeting at Shelburne Wednesday afternoon, the time was principally occupied by Secretary Adams. Not being a large meeting, it was conducted by the other members and farmers present in a conversational way near the close. The discussion was mainly on what to raise, feed, and sell. The board took the train back to Gorham from this point, not, however, without first having enjoyed the hospitality of the Burbank homestead, and taking a look at the fine stock of the various breeds kept there.

Councillor Goodell opened the meeting at Gorham Wednesday evening, and spoke for an hour to an intelligent mixed audience of farmers and mechanics. He was followed by Secretary Adams, some questions being asked by farmers present.

Gorham is a thrifty place of about the same size as Berlin Falls. After breakfast the company visited a lead mine on the other side of the river, some of them going two hundred feet into the side of the mountain. After this we took the road behind four bays belonging to the proprietor of the Ravine House in Randolph, in which town a successful meeting was held in the afternoon, Mr. Whittemore, member for Coös county, giving a paper on breeding, which was well listened to. A vigorous address from the Secretary was also well received.

The same team took us twelve miles west to Jefferson for the evening meeting. We pass the Presidential group, cloud-capped and sombre grey, dotted with evergreen, in the drive from Gorham to Jefferson. At Jefferson seventy-five were present, and Messrs. Adams and Goodell spoke very acceptably to the audience. Unusual interest was manifested in both meetings.

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The party stopped at the Waumbek House. Between that and the Ravine House in Randolph one passes the Mount Adams, Ethan Crawford, and the Highland hotels. There are fourteen sizable boarding-houses and hotels for the accommodation of summer visitors in Jefferson, the Waumbek being the largest. The Brown Lumber Company have made great improvements near the depot in the last five years. During Thursday night a fine rain fell, but all was over before we reached Whitefield Friday morning.

The meeting at Whitefield Friday afternoon was opened by Mr. Whittemore, who spoke on "Breeding," followed by Messrs. Adams, Goodell, and Gerrish, several farmers present asking questions on the various topics, among whom were Messrs. Bray, Dodge, and Hazen. The attendance here was small, numbering about forty.

The evening session, the last of the Coös county series, was attended by nearly one hundred listeners, and Messrs. Adams and Goodell spoke to their satisfaction on "What the best farmers do," and "The East *versus* The West."

Aside from summer boarding, Whitefield is a great place for the lumber business. Mr. Hazen, one of the large lumber operators, has a fine farm and extensive teams, and showed a great interest in the meetings. He is the owner of the Percheron stallion that took the first prize at the New England fair at Manchester.

The Brown Lumber Company do a large business here, employing nearly two hundred men. They deal in hard and soft lumber, and manufacture mouldings, butter-tubs, etc. The Libbys also do a good lumber business here. The Jefferson & Whitefield Railroad extends back into the lumber region with its branches.

After a pleasant week we embarked Saturday morning on the Boston, Concord & Montreal Railroad once more, with our headlight towards the south.

As one of the elements—the vital one—in the prosperity of Whitefield and vicinity, we refer to the Brown Lumber Company and its reorganization by copying a current item of the newspaper press:

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"Few people are aware of the magnitude of the business done by Brown's Lumber Company of Whitefield. They own 30,000 acres of land, located in Whitefield, Carroll, Jefferson, and Randolph, and the Low & Burbank Grant of 14,000 acres of original forest. Their mills give constant employment to about one hundred men, and produce daily 50,000 feet of lumber, consisting of dimension timber, boards, shingles, laths, clapboards, house finish, shooks, dressed lumber, etc.

"Power is furnished by a 400-horse-power engine, and the mills and yards are lighted by electric light. The company also own forty houses and tenements, two stores, one half interest in the Whitefield & Jefferson Railroad, over which logs are brought from the forest to their mills, besides three miles of track laid into their woods especially for their use. At present they have three hundred men and one hundred horses and cattle at work in the woods cutting from 600,000 to 800,000 feet of logs per week, besides hundreds of cords of wood.

"Heretofore this great lumber-producing corporation has been owned by four different individuals, but advancing years and the failing health of Dr. Aaron Ordway, of Lawrence, the owner of about one third of the stock, has necessitated his retirement from any active participation in its management. Arrangements have been completed whereby his entire interests have been closed out, and gentlemen of wealth and business standing have become stockholders and interested in the company. Among them, we understand, may be mentioned Ossian Ray of Lancaster, J. W. Johnson of Boston, Walter Aiken of Franklin, A. G. Folsom of Laconia, Judge Poland of Vermont, George Leslie, cashier of the bank at Wells River, Charles W. King of Lunenburgh, Vt., besides several Manchester gentlemen. Nathan R. Perkins, of Whitefield, is president of the company; A. L. Brown of Whitefield, agent; Charles W. King, of Lunenburgh, Vt., treasurer; Messrs. A. L. and W. G. Brown, N. R. Perkins, Ossian Ray, Charles W. King, and Henry Chandler constitute the board of directors. One unaccustomed to large lumbering operations, visiting the mills, yards, and camps of the woodmen during the operations of this company in a busy season, would be impressed with the colossal character of this New Hampshire enterprise, as it is beyond all question the largest of the kind in New England."

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## MEETINGS IN CHESHIRE.

The board held meetings at Fitzwilliam and Harrisville, in Cheshire county. Messrs. Harvey, Hills, and Adams attended, and at both places the farmers and their families, with many village people, were present. Among the topics discussed were stock, ensilage, fruit-culture, and garden vegetables.

Mr. Harvey, of Surry, who has had three years' experience in feeding ensilage, said he had but little to say in regard to it that he had not before said. The more he used it the more confidence he had in its utility. He had fed it to animals by itself and with dry feed, with and without grain, to cattle old and young, for milk and for growth, and in every case it had proved more valuable than an equal cost of hay or any other fodder. A ton of good hay is not worth more than two tons of ensilage. Mr. Harvey gave the analysis of ensilage, as obtained by the secretary of the board of agriculture. It is as follows,—

| | | |
|---|---|---|
| Moisture at 100 degrees, | 84.607 | per cent. |
| Ash, | .953 | " |
| Acetic acid, | .028 | " |
| Fibre, | 3.88 | " |
| Sugar (glucose), | .53 | " |
| Fat—Ether extract, | 1.20 | " |
| Nutrition. | | |
| Albuminoids, | 1.25 | " |
| Carbohydrates, | 7.552 | " |

Mr. Harvey said it is true that seventeen twentieths are water, less than one per cent. is ash,—that there really is not an excess of nutritive material in it; but there is one item brought out by the secretary's analysis which tells in favor of ensilage. It is, that the ratio of the albuminoids and carbohydrates is as one to six,—almost exactly the same as excellent red-top and other fine qualities of well made hay. It takes a large quantity of the feed to satisfy, but the ratio of elements is all right.

Now another point that Mr. Harvey made is this, that the manure made from ensilage alone—no other feed given for a week—is not of great value. This was ascertained by an analysis, made by order of the secretary. It is as follows:



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| | |
|---|---|
| Inorganic matter, | .388 |
| Moisture at 100 degrees, | 83.890 |
| Organic and soluble matter, | 13.270 |
| Nitrogen, | .496 |
| Silica, | .005 |
| Phos. acid, | .163 |
| Sulphuric acid, | .054 |
| Ferric acid and alumina, | .010 |
| Potash, | .140 |
| Soda, | .023 |
| Sodic chloride, | .012 |
| Carbonic acid, | .700 |
| Magnesia, | .470 |
| Lime, | .385 |

Mr. Harvey stated that these analyses were the fullest of any made, and of great value in a discussion of the subject. The value of the manurial elements, potash, phosphoric acid, and nitrogen, for a ton of the dry manure, is about four dollars.

Mr. Adams discussed the matter of breeding at great length. We will give a few points.

He advised a study of the animals the farmer owns, and select from them the females of the best points for breeding; but use pure-bred sires in all possible cases. Why? Because, if properly bred, they will possess the accumulated good points of many generations, according to the special object for which they have been bred. Breed, too, from those animals that have a high record for butter, milk, or beef, or for whatever specialty is desired.

Do n't breed from deformed animals, or those of weak constitutions, or having any disease, or having suffered from accident. Neither breed from those of vicious tempers or objectionable habits of any description.

He would be careful in regard to the first amour of animals, for the benefit to ensue in the subsequent production of young. Do n't use very young animals as breeders; wait for a reasonable degree of maturity. Breeding-animals may sometimes be too old, but not often. An old sire will give better progeny than young ones, though it may not be so numerous. Close breeding may be practised only by experienced breeders.

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Mr. Hills discussed fruit-growing,—apples, pears, and small fruit.

At the Fitzwilliam meeting, Deacon Buffum, of Winchester, a former member of the board, was present, and addressed the meeting with much spirit, though now more than seventy-five years old. Colonel Reed of Swanzey, Captain J. S. Adams of Fitzwilliam, Mr. Cahill, and others, spoke at the Fitzwilliam meeting.

At the Harrisville session there were present farmers from the neighboring towns of Nelson, Dublin, Hancock, Greenfield, Bennington, etc. Mr. Lakin of Hancock and Mr. Russell of Greenfield took part in the exercises, as did also Hon. Aaron Smith.

At these meetings Mr. William H. Hills, of Plaistow, member from county of Rockingham, gave a talk on market gardening, in which the following statements were made:

In those towns near large cities, where "garden truck" is produced, where there is employed one man to an acre of land, a thousand dollars a year are taken for the products sold. The gardeners are shrewd, sharp men, who make every action tell. It is a hard trade to learn, and is sometimes inbred. They apply from ten to twenty cords of manure to the acre. The speaker gave an example of a gardener on whom he had called. The gardener was communicative of plans and practices, but said no one can learn all without practice. It requires practice and a long apprenticeship. The soil must be good, underdrained, and thoroughly tilled. All early crops must be started under glass. Cucumbers are grown under glass, and at first sold at ten or twelve cents apiece, and so with other crops. Celery was instanced, and an explanation made of how it is grown in winter. Onion sets are profitable. They are sown at any time, regardless of frosts. Celery is sown between the rows, and after the onions are harvested the celery is given the soil. Beets for greens were discussed, cabbages also. Acres cropped with early beans are sowed with beets for winter use. The early Wakefield cabbage was spoken of as the best for early market. Among the early cabbages are planted hills of squashes, which occupy the ground as a second crop. Hot-bed frames were described, made on the ground by the use of tim-

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bers six inches wide, laid parallel and filled with horse manure; afterward loam is spread on, and the seeds are put in.

He spoke of storing squashes so that they do not touch, but are easily accessible, in a room of moderate temperature, at about forty-eight degrees—considerably higher than is required for apples or potatoes. These, in winter, are sold high, at three or four cents a pound. How about bugs? asked a hearer. The little striped bug haunts the vines. I subdue them by the use of Paris green and plaster, or green, one part to 100 of water, sprinkled on as we do on potatoes.

In making pickles, put washed cucumbers into weak vinegar for twenty-four hours, and then transfer them to first-rate cider vinegar. Strong vinegar will not eat up pickles.

The squash-borer is a fatal enemy, caused by a fly. The remedy must be something that, by its smell, will drive them and the fly away. The fly that lays the eggs of the onion maggot acts between the 10th and 20th of July. Ammoniacal substances scattered about will drive away the onion fly. Quicklime in gas tar will drive away the insect. Hen manure steeped will do the same. I use salt on onions. Can get it in Boston at low prices. Would apply salt on most garden crops, and on young trees. Onions must follow cabbage, beets, or turnips, but never follow the carrot. Onions require firm land.

### MEETING AT PLYMOUTH.

It was understood that the Plymouth meeting would be a union with the annual meeting of the Grafton County society, and notices were given accordingly in the surrounding towns, but were not well circulated at the "Railroad hub." Plymouth is great on railroads, and much on normal schools, but rather below zero on agricultural meetings, except at the time of the local fair.

No bills could be found posted in town, while the storm kept outsiders away. There was no Grafton society to be seen or heard, except President Keyes of Ashland, Secretary Baker of Rumney, and Executive Demming of Bath, but they could n't count up a quorum, and therefore adjourned. At the time for the meeting the hall was shut and cold, and a snow-bank was piled before the door to keep out tramps. The key was found,

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entrance gained, and a fire was soon burning. One by one hearers came in, until a fair audience was gathered. In the evening still more were present.

The talking was mostly done by Messrs. DeMeritte and Goodell, Messrs. Carr and Adams taking a minor part. The topics were "Grass-Growing," by Mr. DeMeritte, who runs a grass farm in Durham. He sells hay and buys fertilizers, but believes the fertility can be maintained in part by cultivation. He plows a little deeper each time, making more soil and securing better harvests. He made one essential point, which is embraced in this: Do not manure so heavily as to cause grass to lodge. This indicates a waste. Manure and plow often, but avoid the danger of manuring too much at once. His soil, which is somewhat heavy, is benefited by working as much as by manuring. His method of seeding is, by preference, to plow in the summer, and lay down to grass before September. Sometimes he sows later; has done it in June, on flat, cultivated corn-fields, at second hoeing; has also sown grass-seed on the snow in March or April. Applies herds-grass, red-top, and a little clover seed—none of them very heavily.

Mr. Goodell spoke on the silo and its uses, advocating it for all farmers, especially for those of limited means.

In the evening Mr. Goodell made an eloquent talk on "The East *vs.* The West."

Mr. Adams and Mr. Carr made short talks on potatoes. Mr. Weeks of Rumney, and Mr. Baker of Quincy, in the south part of Rumney, interrogated Mr. Goodell in regard to ensilage, and secured intelligent and satisfactory answers.

### MEETING AT LISBON.

At Lisbon the meeting was an enthusiastic one, there being a large attendance, including ladies and young people. Lisbon is a good farming town, producing really all the staple crops of the north. At the opening of the meeting, Mr. Carr, who presided, gave his experience in growing potatoes, and said that in his town (Haverhill) there were two hundred carloads to spare. They would go to the market, but there is no market. His advice was to feed them to stock with other feed: they are very serviceable. He can grow corn after potatoes with a small

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dressing, and then put in wheat. He raised sixty-four bushels of wheat on two acres the past year.

Mr. Adams followed on the subject of manure. He believed in the best manner of pulverization and good culture. Let the soil be worked, and it will have available plant food. Animal manures are rich if well cared for, and made from rich material. They help retain moisture: they create mold or loam, and are lasting.

Mr. Adams also, at another hour, showed what crops to grow to sell, and what to feed. In short, those to sell are such as take but little from the soil,—hay at $15; wheat at $1.50; corn at common prices; all condensed products, as pork and fat meats of any kind, eggs, fruit, etc. Those which should be consumed on the farm are clover, oats, and all that cannot be sold for more than they cost.

Mr. Hollister, of Montpelier, Vt., made a statement regarding his silos, which seemed to convince his hearers of their utility. He was followed by Mr. DeMeritte, who advocated the acquiring of such skill by farmers as will enable them to grow large crops in adverse years. It is no credit to grow a good harvest of any crop when everybody has an abundance. He dwelt on the intelligent management of the soil, and urged care in the application of manure so that it may bring good harvests.

Remarks were made by Rev. Mr. Lee, which were original and appropriate.

### ANOTHER REPORT.

A correspondent of the *Mirror* gives the following account of the Lisbon meeting, which the secretary copies as supplementary to the *Union's* report:

According to previous arrangements, the board of agriculture held a meeting at the town hall, Lisbon, January 10, at 2 P. M. As was expected, there assembled a goodly number of the most intelligent and progressive farmers from Lisbon and the adjoining towns

The meeting was called to order, and addressed, first, by Mr. Carr. This gentleman is now a member of the board; was formerly a well known student of Newbury Seminary, and is now a practical farmer in the town of Haverhill. He spoke to his brother farmers in an easy, conversational style, principally

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relating his experience in the management of different crops. His method of cultivating wheat and potatoes specially commends itself to the consideration of intelligent farmers. His instructions practically apply to those living in this part of the country, since here is his place of residence and the field of his experiments.

Next came upon the stand the veteran member of the board, Mr. Adams, who, in his usual humorous and off-hand style, dilated upon the subject of manures and their application. His remarks were interesting and instructive. Being a good-natured and approachable man, he apparently enjoyed being interrogated, and holding short discussions with the farmers present. His theory, that manures should be applied as near the surface as possible, provided they are covered, seemed to meet the general approval of the audience, but not much stock was taken in his advice to spread manure on the snow, upon our uneven lands. This procedure certainly does not accord with the experience of the correspondent, unless it is deemed more necessary to enrich the lower part of a hillside than the portion near the top. His statement, that capital is just as necessary for the farmer to carry on his business as for the merchant, should be taken with some degree of allowance. No farther back than the generation to which belonged our parents, young men would purchase farms, running badly in debt, pay for them, and come out forehanded. The same could be done now, if the individual possessed independence to discard the extravagance of the times.

At the conclusion of Mr. Adams's remarks, Mr. DeMeritte came forward, and addressed the audience upon his favorite topic, the "Grass Crop." His words were well chosen, and his speech throughout evinced a thorough knowledge of the subject. It is generally conceded that of all the crops raised in New England, the grass crop is the most important. Hence the injunction of the speaker, that the farmer in all his transactions should keep in view the grass crop, seems altogether appropriate. Suppose a man takes upon his hands a worn-out farm which annually yields thirty tons of hay, each year sells a large proportion of his crop, makes all necessary repairs upon buildings and fences, pays all bills from the proceeds of the farm, and in ten years brings the product of his farm up to 100 tons

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of hay—the speaker claims to have done this, and we believe it to be true: then what have we to say? We must acknowledge that farming has become a science, and none are too old to learn. Mr. DeMeritte supplemented his speech by remarks upon the dairy business and the feed for cows, after which the meeting closed.

At the opening of the evening session, the spacious hall was nearly filled with farmers and citizens from the village, including many ladies.

Mr. A. J. Hollister from Vermont, an educated farmer and the owner of a silo, being present, was called to the stand. Mr. Hollister stated that he built a silo three years ago, and had used it since, much to his advantage. He demonstrated that one can be built with little expense, which will answer all purposes. Then he gave a description of his own silo, and the *modus operandi* of raising and preparing the food, and distributing it to the different kinds of stock. As considerable interest was manifested, it is probable that some of our farmers will try Mr. Hollister's experiment.

The balance of the evening was occupied by Messrs. Adams and DeMerritte, in discoursing upon general farm topics. Space does not permit us to follow their speeches in detail. Suffice it to say, that such meetings, under the direction of such men, can but have a salutary influence, and if they were more frequent the farmers would become more intelligent, and their occupation would be more respected.

On the return from Lisbon, Messrs. Adams and Carr visited the fine little town of Belmont, and held afternoon and evening sessions. Most of the talking was done by the secretary, whom Dr. Hackett announced as ready to speak on theology, education, or agriculture. The meeting manifested a good degree of interest.

One of the prettiest incidents occurred here. Mr. Brown, the hotel keeper, had a pair of oxen, most perfectly trained, which he had just sold for $315. In parting with them the old man cried, and said they were as dear to him as his own children. He was accustomed to spend hours with them, and never allowed himself to strike or scold one.

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### MEETING AT NASHUA.

On Tuesday, the 11th of February, members of the board of agriculture met in grange hall, Nashua. The first topic was that of "Stock Breeding." Mr. Humphrey, of Concord, opened the discussion, and spoke of the importance of making selections for breeders, avoiding ill-formed, vicious, or diseased animals. He cited cases in his own experience of spavin transmitted from the horse "Bell Founder," and viciousness from "Old Finance." He next took up the matter of breeding milch cows for butter or for milk, and urged that for dams and sires only those be used that have records showing great excellence in the specific line. The speaker condemned the breeding of fast horses. Leave that to the jockeys. If perchance the farmer has a promising colt, he should sell at the first reasonable offer. The best to raise is the one adapted to family use. The horse-railroad horse, worth from $125 to $150, is now a profitable one to raise. A hundred thousand horses in four years are used up on horse railroads in this country, or 25,000 a year, the horse lasting only about four years. Mr. Humphrey condemned dog-raising and dog-shows, but would raise sheep, and also swine.

Hon. D. H. Goodell endorsed the doctrine taught, and presented a case in point.

Ex-Mayor Gilman, of Nashua, spoke of breeding Jersey stock, being in love with farm work, and especially stock management. He keeps cows for the sale of milk and cream. Has pure bloods, but not registered. Would advise the use of pedigreed animals. Prefers small breeds of swine. Does nothing in horse breeding: has had enough of it. He would raise good horses rather than fast ones. The old Morgans are the best horses we ever had in this section of the country.

Secretary Adams spoke of the depreciation of our farms from continual cropping, and neglect to return adequate fertilizers. Special manures will not meet the demand, and we cannot buy animal manures. We must raise cattle if we would keep up the productiveness of the soil. To do this, we must at first buy feed that will make good fertilizers. Now, then, in raising domestic animals, we cannot afford to buy pure bred stock at present prices. We must have pure bred males, and make

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selections of females, constantly choosing the best animals. Take healthy, vigorous animals for dams always. If close breeding is practised, only the most thorough knowledge is safe. Ignorant breeding will bring disaster. Do not breed from very young animals, nor from very old ones. Let stock animals be worked moderately.

Mr. Morse, of Lowell, occupied a little time on "Market-Gardening," and was followed by Mr. Hills, of Plaistow, on "Fruit-Culture." Afterwards Mr. Goodell, of Antrim, spoke on the contrast between the East and the West.

### MEETING AT FRANKLIN FALLS.

The report of this meeting is from the ready pen of the agricultural man of the *People and Patriot*, James L. Gerrish:

This meeting was well attended by farmers from Franklin and adjoining towns, the sleighing being good. The afternoon meeting was attended by about seventy-five persons, and was called to order by Mr. W. F. Daniell, who introduced Chairman Humphrey. Mr. Humphrey spoke on the subject of fertilizers. Secretary Adams followed him. Both gentlemen were questioned by Mr. Daniell and other intelligent farmers present, the names of whom were not all announced.

Both these addresses having been reported in substance before, we will now simply notice a few points. Among other things mentioned, Mr. Humphrey said that where he had applied chemical fertilizers several years in succession, he was beginning to fail to get a profitable return. One gentleman in the audience asked where we were to get our formula if we tried to buy the simple elements of fertility, in order to make up such combinations as were needed. Had the question been addressed to us we should certainly have advised him to ask the question of the farm to which the formula was to be applied. No one is so well able to answer correctly as the particular field to be fertilized. Put a few small experimental plots, this year, on land to be dressed for a crop next. Mr. Adams, in reply to a question, said he had done a little better to buy the elements and combine them, than to buy manufactured standard brands of fertilizers.

Mr. Goodell, member of the board, also spoke on ensilage,

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varying somewhat from other lectures on the same subject. Although an earnest advocate, he does not claim ensilage as a perfect feed, in itself, like the good grasses. He was giving his cows at present four quarts cotton-seed meal daily, and meadow hay at noon, giving the ensilage night and morning. He was so successful fattening oxen for market last season that he was repeating it this year. Oxen that he bought in quite thin flesh last fall, are now nearly ready for market. He had never had any complaint as to quality of milk he was sending away except once. It was then traced to "skunk cabbage," fed in the meadow hay. A question being asked by a Sanbornton farmer as to the comparative value of an acre of ensilage corn and an acre of matured Northern corn, Mr. G. said he had not made figures on it, but presumed the Northern corn would be worth as much, but thought it would exhaust the ground much more to mature a crop of ripe corn. It would take extra fertilizers to start the ensilage business, but when once under way the productive capacity of the farm would be doubled, and the stock proportionally increased. He counts three tons green equal to one of good hay, and says a silo can be made in a barn bay costing only one dollar for each ton of ensilage to be stored.

Mr. J. H. Philbrick, of Tilton, showed a good sample of herds-grass and red-top hay raised on reclaimed swamp land, with only a small dressing of manure. He drained it with open ditches, plowed, and seeded. This land formerly cut poor grass. Speaking of witch-grass land, he thought he could seed it better without first raising a hoed crop.

Immediately after the afternoon meeting Mr. Daniell took members of the board and others, to the number of fifteen or twenty, to his farm to see the Jersey stock. Although not the largest, Mr. Daniell has one of the most select herds of registered cattle in the state, the individuals many of them being bought regardless of expense. Besides several young cows raised from "Champion of America," son of "Pansy," he has a "Champion" bull bought in Mississippi, and a younger one sired by a son of "Jersey Bell," of Scituate. His cow "Mariana" took the prize as best cow of any age at the New England fair. This herd now numbers about fifteen animals, most of

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his calves having been sold to go West, at big prices. Mr. D. showed the gentlemen the butter, and the whole machinery and process of making. He uses the "Cooley" deep cans for setting, the "Stoddard" barrel churn, and makes very small prints with a press. The butter made from one cow, "Matilda Pond," showed nearly June color. In fact, the hay and rowen made by the abundant fertilization at his command makes it possible to make the best of butter from such cows, even in winter. Mr. D. also showed a Morgan blood mare and five or six colts, and some good hogs. Four of the colts are from "Mambrino Wilkes." His mare is due to foal March 15th, which colt, if dropped on time, will be the fifth this mare has produced in three years and eight months! After viewing the barn and stock, members Adams, Goodell, and Carr, J. B. Walker, and your reporter, were invited to sit down to an entertainment by Mr. Daniell and wife, in their pleasant home. These people have not only a beautiful, but a convenient and cozy, house. Mr. D. and wife are both approachable and social people, and without effort made their guests happy the little time they could stay.

The evening session was attended by nearly two hundred people, we should judge. In the absence of Mr. Hills, of Plaistow, the talk on fruit was conducted by a gentleman from a neighboring town, who has some experience in such things,—Mr. Sawyer, of Salisbury,—and gentlemen whose names we did not learn. It was thought that the seedling grafted sometimes affected the quality of apples, as did also the kind of soil on which they grew; that possibly the appearance of the "apple maggot" would make it necessary (unless it soon disappeared) to regraft many sorts with such as it was found by experience they did not prey upon to any great extent, they at present seeming to care more for early apples and sweet fruit, preferring them to either the very tart, or very hard and late, varieties.

The apple talk was followed by Joseph B. Walker, on grass. Mr. Walker, being one of the most agreeable talkers, nearly always speaks in the evening when the largest crowd is expected. For this reason, and the fact that his language is so well chosen, we dislike to cut up his excellent essay into frag-

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ments, after having reported an afternoon meeting to the extent of our accustomed column. Mr. W. said: Our 600,000 tons of hay ought to be doubled, and might be if New Hampshire farmers would only have faith and enterprise. He spoke of the immense crops taken in England where sewage is applied in liquid form. The drouth was our worst enemy. We must work our grass lands oftener, and better, thus preventing evaporation to excess. If we double our grass product we can double our stock. Select moist land for grass production.

Recapitulation—1st. Raise grass on grass land. 2d. Frequent and thorough cultivation and drainage. 3d. Abundant fertilization under such conditions as will insure large crops of hay.

The remainder of the evening was occupied by Mr. Goodell's lecture on "New England," which was well received, although necessarily abridged on account of the lateness of the hour.

To the credit of all concerned, the Franklin Falls meeting must be put down as a success.

### MEETING AT CONTOOCOOK.

The *People and Patriot* reported the meeting as follows:

The meeting was called to order by Mr. Humphrey, chairman of the board, who spoke on the subject of Fertilization. He said he would not confine himself to chemicals. It is a great problem how to keep up our farms. There are no two farms alike, but all need different treatment. Cheap feed makes cheap manure. It requires judgment to tell what kind of land the manure from different farm animals should be applied to. Manure from cotton-seed meal and shorts is worth more than that from poor hay. By feeding these we obtain good fertilizers ready to make good returns.

Chemical manures can be used profitably if applied understandingly, much depending upon the season; but there is a point where its application in a certain direction must cease to be profitable. Ashes are good on some lands, while on others they are hardly worth the labor of carting. Hogs usually pay expenses, and more; and if properly managed and the right breed kept, they help greatly in fertilization. Some have advocated the plowing in of green crops, but that takes a great deal

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of courage. He advised young farmers to try experiments, and learn for themselves. Whatever or however fertilizers are applied, there must be thorough pulverization of the soil in order to get immediate results.

He was followed by Mr. Adams, the secretary, who spoke from a scientific standpoint in illustration of the subject. The necessity for fertilization comes from the unfortunate fact that farmers have taken more from the soil than has been returned. Primarily, manuring means hand-working. He then took up the reasons accounting for results in fertilization. Animal manure is the best we can have, if rightly saved and applied. Farmers are wasting manures, at all points, in a wanton manner. The loss by evaporation is not as much as was formerly believed, and in a degree not to be compared to the loss by leaching. Liquids should be saved by absorption or in cemented cellars.

The roots of plants usually occupy the first four inches of the top soil. Apply the manure there. He believed in manuring land when you have time to attend to it. He would not be afraid to apply to plowed lands in late fall or winter. Cattle will not thrive on feed that does not contain sufficient phosphoric acid: this may be supplied in various forms from bones. Potash is cheap, and a necessary element in some cases, but nitrogen is the most expensive to buy. It comes from blood, and other wastes of the large slaughter-houses.

Special fertilizers that we buy most have these three elements in their composition, and in order to use them intelligently we need to be acquainted with the wants of our soils, and buy with special reference to their needs. The broad-leaved plants do not require so much nitrogen as was formerly supposed. Animal manures must be used in connection with minerals, or crops must be plowed in instead, on light lands. Our law requires a license of $50 from manufacturers of fertilizers, and obliges them to label them with the per cent. of each of the leading elements in their composition. Do n't buy unless they have this label. The nitrogen is considered a little more valuable per cent. than ammonia. Soluble phosphoric acid is better than insoluble for present use.

Mr. J. M. Connor was invited to say a word. He believed it

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pays to feed purchased foods, such as cotton-seed, bran, and corn, and thus get the fertilizers. He had been cautious, but he now believed that if fed to good stock with judgment it would pay. He did not believe in feeding it to stock, and letting them waste it running over the fields and lanes, or feeding it to teams made to work for seventy-five cents a day, and dropping the manure on the road and in the woods. They do not need the corn for manure-making in the West: we need it. He wished farmers were not too self-righteous to go to farmers' meetings. He wished there were more present to-day. We need to think, and then confer together.

EVENING SESSION.

Joseph B. Walker, of Concord, spoke on Forestry. We can give very little of his lecture, but presume it will appear in due time, as he is a member of the forestry commission. He first stated that New Hampshire has, in round numbers, about six million acres area. Only two and one fourth millions are cleared of forests, and really only about one million acres are subject to the plow, showing our forest interest to be a very important one,—the annual product amounting to $4,500,000, as compared with strictly agricultural products to the amount of only $13,500,000, all counted. Rightly managed, the forests will yield an annual good income, without plowing, hoeing, etc., Providence evidently making an exception with this crop, it not requiring much "sweat of the brow" to get it. He criticised the methods of forest management. Farmers do not always know the actual value of such property, often selling in a lump for much less than the actual value, often investing the proceeds in wildcat speculations and in other ways. He would recommend some system in the management of the forests. What this system is we shall be obliged to condense, simply saying that timber should be regarded and handled as a *crop*, like anything else.

Meetings were also held at Woodsville, Exeter, Newport, Cornish, and other places, but the weight of the talk was the same as has been already reported. At Exeter, Dr. J. R. Nichols gave his eloquent lecture on Sunshine, published in our

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last volume. Mr. Walker carried on most of the meeting at Cornish, taking the place of the secretary, who had not been absent from a meeting before for eight years. At Woodsville, Dr. Watson read a valuable paper, which we hope to print in this volume. The meetings, which number thirty the past winter, have been well attended, and give evidence of an advance in agricultural knowledge.

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# ADDRESSES AND PAPERS

BEFORE THE

## BOARD OF AGRICULTURE.

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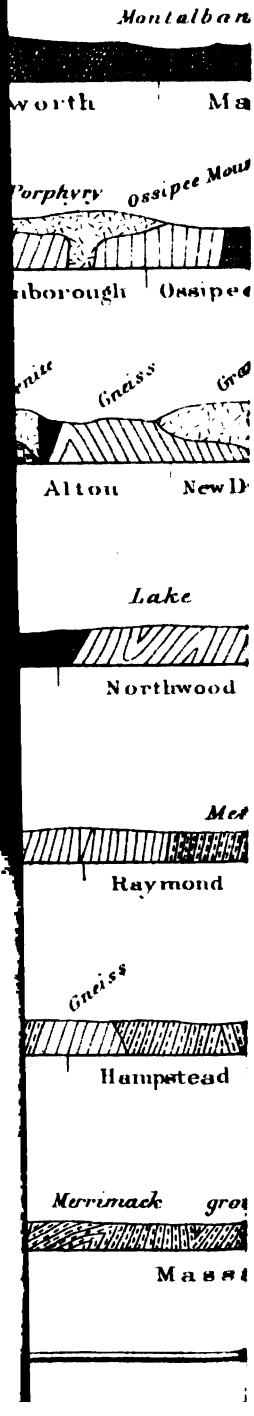


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# DESCRIPTION OF GEOLOGICAL SECTIONS CROSSING NEW HAMPSHIRE AND VERMONT.

BY PROFESSOR C. H. HITCHCOCK.

Six years ago the final report upon the Geology of New Hampshire was published by order of the legislature. Since that time the author of this paper, who held the office of state geologist, has had occasion to revise the general sections described in his report, and also to extend them through Vermont. Specimens to the number of three thousand illustrate them upon the shelves of the museum of the New Hampshire College of Agriculture and the Mechanic Arts, where colored profiles will also be found upon a liberal scale. The profiles are forty feet long, extending the entire length of the room upon the back side of the case and between the shelves. The different series of strata are represented by colors, and the numbers printed upon the profiles correspond to those pasted upon the specimens directly in front. Thirteen shelves are arranged in order, one over another, from the floor to the ceiling. Care is taken not to impede the view of the colored profiles by braces or railing in the gallery, so that the visitor may examine the whole series either in detail or at a glance. These shelves are a truthful representation of nature. Three thousand ledges are represented in their proper geographical order, and by proper study any one can classify the several groups without the labor of travelling over the country. More or less of theory is given in the profiles, and the author is desirous of having his views submitted to criticism. The conclusions derived from the study of these sections have been embodied in the reports upon the geology of

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both New Hampshire and Vermont; but a resurvey of them has enabled me to correct doubtful points, to confirm truthful representations, to change the published section lines where improvements were possible, to take advantage of observations made by other observers, and to present a connected view of what has been learned concerning the geological succession in the two states. A knowledge of this territory furnishes the key to unlock the mysteries of New England geology, as well as that of the whole of the middle section of the Atlantic geographical area. In the same room at Hanover may be seen a large colored geological relief-map of New Hampshire upon the scale of one mile to the inch horizontally, and one thousand feet to the inch vertically. Portions of Vermont are also shown, and it is our purpose to show the whole of that state, as well as a part of Maine, upon the same platform. These relief maps and half of the specimens illustrating the Vermont sections belong to Dartmouth college.

A similar collection of specimens is on exhibition at the rooms of the American Museum of Natural History in New York, together with the same large relief-map of New Hampshire, colored to correspond with the published geological map of New Hampshire. A special description of that has been printed in Bulletin No. 8 of the publications of that institution. At the normal school in Plymouth there is a similar exhibition of the New Hampshire part of this collection, but no attempt has been made there to group them in order upon shelves accompanied by the colored illustrative profiles.

Our object in preparing this sketch is to so record the most important facts connected with our explorations, that those who visit Hanover may have the opportunity to verify our conclusions for themselves by studying the specimens, both lithologically and stratigraphically. The work of exploration was undertaken with the determination to discover what the rocks themselves taught, and not in the interest of any theory. Hence students may rely upon the truthfulness of all the representations. The specimens come from ledges in the localities indicated, and the positions of the strata are stated according to our best judgment from personal observation. If there is ever any want of symmetry in the folds, if one side of an axis seems

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to possess an exaggerated thickness, it is because all the facts needed for full delineation are not known. Pains are taken not to represent curves and faults except those whose existence is unquestionable. Hence the inquirer can utilize the ten years of field and office work embodied in these collections nearly as well as if he had gone over the ground himself. He will also understand for himself the localities where supplementary observations are needed.

About 90,000 feet thickness of strata occur over this territory. As they have not been particularly investigated elsewhere, it follows that many groups must exist not generally recognized, and peculiar designations must be employed which will be perplexing. To assist the inquirer, I will, at first, present a few general conclusions, based upon a terminology readily understood, reserving the fuller details of our scheme of classification and structure for the sequel, to be fully appreciated only by a painstaking examination of the larger profiles and specimens in the cases.

It should also be borne in mind that our various groups or formations are classified according to stratigraphical reasons, and not lithology. Lithological names may be used for convenience, or so as to avoid the multiplication of local designations. A lithological similarity is useful in tracing a formation from farm to farm, or town to town, throughout a county, or to identify the opposite side of a synclinal basin or anticlinal ridge. Furthermore, unlike rocks are never assumed to be identical. If a hornblende schist and clay slate dip toward each other, they are assumed to be of different age and separated by a fault or unconformity. All the igneous rocks of our field are held to be truly eruptive, and are devoid of marks of stratification. If a granitic rock shows foliation, it is classed among the gneisses.

The published sections accompanying this paper have the horizontal scale of $\frac{1}{300000}$, and the vertical of about $\frac{1}{150000}$. They are arranged geographically correct with reference to each other, and the meridians and longitude are drawn as upon a map. In some cases the extreme east or west ends of the sections are not represented. The base line of all the sections is 1650 feet below tide-water. Twelve variations of lines, dots, and dashes indicate as many groups of rocks upon which our primary con-

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clusions are based. They are,—1. *Niagara group. 2. Upper Cambro-Silurian slates and schists. 3. Cambro-Silurian limestones. 4. The Connecticut Valley mica schists, quartzites, etc., referred to the Coös group in the New Hampshire reports, and the calciferous mica schists of the reports of both states. 5. Potsdam sandstone. 6. Clay slates and argillitic and other schists, supposed to be of Cambrian age. Of these, the "Georgia slates" of the Vermont report contain the *Olenellus* and *Angelina;* the others have not yet yielded any organism. 7. Mica schist of eastern New Hampshire, a part of the "Rockingham group" of the report. 8. Huronian, including the chloritic, argillitic, dioritic schists, quartzites, and protogenes flanking the Green Mountains, and adjoining the Connecticut river, or the rocks usually referred to this group by authors; also the "Merrimack group," "Ferruginous slates," "Kearsarge group," and part of the "Rockingham group" of the New Hampshire report. 9. Montalban rocks, as defined in the New Hampshire report, including the schists holding the coarse granite veins carrying merchantable mica. 10. Ordinary gneiss, including the "Green Mountain," "Lake Winnipiseogee, and "Bethlehem" varieties of the reports. 11. Porphyritic gneiss. To these may be added another distinction for the unstratified rocks, in which are embraced granite, syenite, and porphyry.

### THE CAMBRO-SILURIAN.

Probably the whole of this division of the Paleozoic rocks occurs in the Champlain valley. Sections I to VII display a mass of green hydro-mica schists overlying the fossiliferous limestones of this series, and may, perhaps, represent the Loraine slates of New York. On our section lines the Trenton is wanting in immediate contiguity to these schists, so that the question arises whether these schists may not represent beds that were laid down in the Trenton age. So far as recognized, the Trenton beds are limestones; but there must have been sediments coeval with those limestones in the ancient seas: still it is but a rude conjecture that would refer them to this age. They are called Loraine upon the sections. These beds were called "Magnesian

*Formerly regarded as Lower Helderberg, but recently shown by Prof. R. P. Whitfield to belong to the Niagara.—*Am. Sci. Jour.*, III, vol. xxv, p. 368.

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slate" by Prof. Emmons, and constituted the upper member of what he styled "Lower Taconic." The relations of the limestones to the schists are well shown upon section IV in Mt. Eolus. There about 500 feet of the schists are isolated from all connection with the main range, and rest upon about two thousand feet thickness of limestones, almost horizontal except at their base. The same schists reappear in what is called the Taconic range of mountains, a few miles west of Mt. Eolus. They universally dip east, and would be regarded as older than the limestones except for the section in Mt. Eolus. This fact has led to careful search at the junction of the two formations for evidence of a fault. Section V shows this break very plainly in Tinmouth. Section I affords the most satisfactory evidence of the passage of the limestones beneath the schists of the Taconic range. At North Pownal a fault has brought up the limestones from beneath the heart of the mountain range. To the east, near the Massachusetts line, the limestones dip west toward these schists, contrary to the nearly universal position of these rocks west of the Hoosac Mountains. By following the Troy & Boston Railroad to the north from North Pownal, we find the limestones nearly or quite continuous to Hoosick Falls, where the characteristic fossils of the Chazy and calciferous sandrock occur in them. This section, therefore, demonstrates the inferior place of the limestones as compared with the schists. This is in the heart of the classic Taconic grounds, where the late Professor Emmons deduced the conclusions giving rise to the existence of the noted Taconic system. I cannot ascertain that he discovered this western dip in Pownal, and the consequent connection, ledge by ledge, of his Stockbridge limestones with the Chazy and calciferous at Hoosick. It is just here that the fatal defect to the establishment of the Taconic system, as defined by Emmons, exists. His paleontological arguments were better than the stratigraphical.

### THE CAMBRIAN.

On the west flank of the Green Mountains, sometimes rising higher than the main range, is a band of quartzite, which received from Emmons the appellation of "Granular quartz," and

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it was made the base of his Taconic system. Our sections show that it immediately underlies the calciferous sandrock, and having fossils similar to those found elsewhere in the Potsdam sandstone, it is clearly a member of the Cambrian series. In some quarters the effort has been made, unsuccessfully, to refer it to the Middle Silurian sandstones. Upon sections III and VII, besides other localities mentioned in the 1861 report, the basal beds contain pebbles of blue quartz, which are recognized as having been derived from the adjacent gneisses of the Green Mountains. Hence this quartzite has been formed since the elevation of the Green Mountains above tide water. The calciferous sandrock had its origin posteriorly to the quartzite, and likewise the several other members of the limestone group in their turn, and there is a natural order of succession in time of the formations from the gneiss to the west.

Three bands of sandstone, therefore, are referred to the Potsdam in the Champlain valley:—first, the normal gray sedimentary beds at the foot of the Adirondacks, always known under this name since 1840; second, the quartzite on the flank of the Green Mountains; third, a range of red sandstone and dolomite from the Canada line to Bridport, where it is succeeded by outcrops of a material not distinguishable from the first-named band. Partly accompanying the middle band is a series of slates and hard sandstones, passing into roofing slates, called "Georgia group" in the state report, which carries such fossils as *Olenellus* and *Angelina*, and is, therefore, thought to be somewhat older than the typical Potsdam sandstone. These are partly connected with a series of schists gradually increasing in thickness and width of territory from section VII, east of Middlebury, to the Canada line. The quartzite first named terminates between sections VII and VIII, save as it may merge into these schists. The continuation of these schists into Canada is an area partly of Cambrian and partly of Levis age.

We can now understand the physical history of western Vermont in the early Paleozoic age. The Adirondacks and Green Mountains had been elevated above the sea, and constituted dry land, connecting on the east with the large Atlantic area—Newfoundland to Alabama—and on the north-west with the generally recognized Laurentian of British America. The waves

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dashing at the Vermont and New York shore lines accumulated the quartz derived from the disintegration of the gneisses into banks of purely silicious sands, frequently termed "primordial sea-beaches." The other materials, of finer texture, were washed out into the deeper waters, but reached sufficiently near the surface to allow of the existence of trilobites, annelids, and seaweeds. At length the silicious sediments ceased to accumulate, and limestones took their place, falling down upon the slaty foundations. In the Trenton age, the last of the limestones, this sea became disconnected with the Atlantic ocean through the present Gulf St. Lawrence, as shown by the distinctively American types of life existing throughout the interior. The limestones were finally covered by the Utica and Loraine slates.

Partial elevations of the Champlain country had been in progress during the building up of the Cambrian and Cambro-Silurian, but there must have been a very important one after the deposition of the Loraine group. The whole Champlain valley seems to have been then raised above the ocean, since no rocks of later age have been deposited in this basin within the limits of New England. The final results of all the elevatory movements have been the crowding towards each other of the primitive land-areas; the faulting of the primal slates; the raising of the beach beneath Burlington and St. Albans—and changing its color from gray to red—overturning many of the limestones and sandstones; developing the symmetrical folds in the red sandstone about Monkton and Ferrisburg; and the alteration of the calcareous beds into snow-white marbles.

## THE GREEN MOUNTAIN ANTICLINAL.

The existence of the anticlinal ridge of the Green Mountains was the most important contribution to science made by the late geological survey of Vermont, though its value was not then appreciated. Nearly all our sections illustrate the existence of this structural feature. Only No. VI is purely monoclinal; and this, like VII and VIII, is to be regarded as an inverted anticlinal. The elevatory pressure seems to have been greatest along the middle part of the state, so as to have overturned this

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main axis. In I a mass of mica schist of undetermined age, possibly Montalban, constitutes the summit of the highest ridge, continuous from the Hoosac mountain over the celebrated tunnel to No. II in Searsburg, where it rests upon the eastern flank of the elevated country. The gneiss is narrowest at the tunnel, and widest along section I, where it may readily be seen to be composed of three parallel axes. The more western one may not extend many miles northerly, and it is more like the typical Laurentian than any other area. Very satisfactory sections are obtained in the valleys of the Winooski, La Moille, and Missisco rivers, cut down across this formation more than 3,000 feet, just north of Camel's Hump, Mt. Mansfield, and Jay Peak (compare IX to XIII). Upon the high mountains the strata are apt to be obscured by extensive deposits of till. Logan's scheme of structure involved the existence of a synclinal instead of anticlinal, while his description of Sutton mountain* showed that the true structure could not be suppressed. Selwyn, his successor in office, declares that the physical character of the region entirely favors the anticlinal structure for the Green Mountains in Canada. Prof. J. D. Dana has also announced his conviction that these gneisses in southern Vermont are older than the quartzite, and of Archæan age.†

In southern Vermont, where the elevated region is widest, the rocks are usually well-defined gneisses, including protogene. North of VI the feldspar diminishes in amount, and at length is manifested in scattered crystals, seen chiefly where the layers are broken. An inexperienced observer will overlook the feldspar upon the higher mountains in the northern part of the state. It is properly a feldspathic mica schist. Adams, the first state geologist, suggested the name of "Green Mountain gneiss" for the whole terrane, in view of this marked lithological feature. We find, on examination, that this micaceous band is probably the equivalent of a mica schist or micaceous gneiss in several gneissic terranes of this age in the Connecticut hydrographic basins in both states, and that it is overlaid by hornblende schist.

It follows, from the relations of the Cambrian quartzites to

* Geology of Canada, 1863, page 251.
† Quar. Jour. Geol. Soc., XXXVIII, 397, 1882.

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the gneiss, that the latter is of pre-Cambrian age. The "primordial sea-beach" defined the western limits of this ancient land. If we use a similar criterion for the determination of the eastern limits of this land, we must travel to Braintree in Massachusetts, or far down in Maine, to find them. There are unfossiliferous quartzites and limestones, probably the equivalent of these western bands, in Plymouth, Vt., Rhode Island, and near the mouth of Penobscot bay. The first are about ten miles in length. There are also areas of slate of undetermined age. In later times the Connecticut valley deepened sufficiently to allow of the growth of Niagara and Helderberg coral reefs.

### CORRELATION OF THE GREEN MOUNTAIN AND NEW HAMPSHIRE GNEISSES.

The sections will enable us to proceed a step further, and correlate the gneisses just described with those of south-eastern Vermont, the Connecticut valley, and both flanks of the highlands between the Connecticut and Merrimack rivers in New Hampshire. First of all, upon Nos. II, III, IV, and V the Green Mountain terrane repeats itself in the well-defined range marked on the Vermont map as extending from Halifax to Hartland. Next, passing the small Guilford, Brattleboro', and Vernon areas, we find the terrane again rising with greater width from Winchester to Fitzwilliam in I, Swanzey in II, Surry, Gilsum, and Stoddard in III, but largely covered by later rocks, Acworth and Lempster in IV, Croydon and Springfield in V, Hanover and Canaan in VI, Orford and Wentworth in VII, Haverhill and Benton in VIII, Bethlehem in IX, Jefferson and Berlin in X, and Milan in XI. This is the northern termination of the terrane. It next shows itself upon the Merrimack slope, viz., at Peterborough in II, Deering, Weare, and Dunbarton in III, Warner in IV, Andover in V, in very limited amount. It seems on this flank of the highlands to lie more in small patches than as a broad belt. The next appearance of this gneiss is in the remarkable range from Mason (I), through Milford and Amherst (II), Manchester, Candia in III, Northwood and Barrington in IV. This range is characterized by the thoroughly crystalline saccharoidal aspect of the constituents. No one

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familiar with typical Laurentian ground will find himself far from home between Mason and Deerfield, nor in Berlin and Milan at the north-eastern extremity of the previously mentioned gneissic wave.

Upon V, VI, and VII is another conspicuous area, partly coincident with the hydrographic basin of Lake Winnipiseogee. This area, as colored upon the map, suggests a north-west rather than a north-east trend. Compass observations, however, show the north-east to be the common direction; hence, the whole of the original area is not visible, being concealed by later formations. This is the broadest of all of the terranes, and it comes up again in Maine, between Denmark and Bethel. Many would mistake the Winnipiseogee lake exposures for granite, but the lines of foliation can almost always be discerned. The difficulty of distinguishing the two rocks is greater in the Maine than the Lake terrane. The descriptions given by Selwyn to the oldest Laurentian gneisses of Canada will apply well to those in the lake district. The next fold is seen at Nashua and Hudson in I, Hampstead in II, and West Epping in III. There are still other areas of small size below section III, especially in Massachusetts, where our published map shows the north-east terminus of the band which has afforded the *Eozoön* in Chelmsford.

Inasmuch as these several gneissic ranges resemble one another, and exhibit the usual phenomena of stratigraphical connection, whether by folding beneath superior formations or bending over still more ancient groups, it is but a necessary generalization to conclude that they came into existence in the same geological age, and that they are all to be ranked as the equivalents of the Green Mountain series, pre-Cambrian, Archæan, or Eozoic. It may be remarked that the first has a northerly trend in southern Vermont, verging more easterly in the northern part of the state, and not extending into the dominion of Canada more than twenty miles. The other ranges gradually course more easterly, and lie nearly in the normal north-east range of the corresponding terranes south of New England, or in the highlands of New York, New Jersey, and the Blue Ridge of Virginia. We have, therefore, an extensive group of gneissic areas essentially continuous from Newfoundland to Alabama on the Atlantic border of this continent. They are of

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Eozoic age, coeval with the formations of the Laurentian highlands, and developed along a different line of growth. They constituted an Archæan Atlantis, now partially submerged, but playing an important part in the building up of the North American continent.

### THE OLDEST OF THE GNEISSES.

These common gneisses overlie a peculiar rock, whose largest development follows the water-shed between the Connecticut and Merrimack systems of drainage, the tract of highest elevation in the state south of the White Mountains, and the group passes beneath the mountains north of the Merrimack basin. This rock is a gneiss, containing distinct crystals of orthoclase, from one half to three inches in length, which are usually arranged in lines of supposed bedding. A more conspicuous ledge is rarely seen; and hence geologists have universally recognized and described the rock. It is the *Augen gneiss* of Europe, and Logan mentions it as a constituent of the Laurentian in Canada. It is not met with in Vermont.

Nearly thirty areas of this formation have been delineated on the New Hampshire map. The largest extends continuously from Jaffrey to Groton, dips beneath mica schists to rise again in Ellsworth, continues to Franconia, and then underlies the Bethlehem group of gneiss to arise for the last time to the surface at the Wing Road railroad junction. The extreme points thus indicated are 105 miles apart. On section I this rock just rises to the surface in Rindge; on II, the southern extremity of the main range is touched in Jaffrey; on III, IV, V, VI, and VII, the rock is very conspicuous. Two ranges are seen in VI, VII, and VIII, and it uncomformably underlies the other gneisses in several instances. The apparent doubling in VI is occasioned by the crossing of a crooked range. Other rocks interstratified with and integral parts of the formation are ordinary gneisses, hard mica schists, ferruginous quartzites, and fibrolite aggregates. The stratification is often obscure, and entirely obliterated in many localities, or where the crystals of feldspar are irregularly disposed. No lower group than this has been recognized in any sections, or anywhere else in New England.

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### HORNBLENDE SCHIST GROUP.

Having ascertained the stratigraphical relations of the gneisses, we find the first rock covering them to be a band of hornblende schist, occasionally feldspathic, and not unfrequently 1,500 feet thick. It is best understood in the southern parts of our field, partly because better exposed, and partly because it has been less studied in the north. First noticed in the Guilford and Brattleboro', Vt., anticlinals I and II, it was detected only by exploration to hold the same position on both flanks of the Halifax-Hartland gneiss II, III, and IV. On I it also overlies the Green Mountain terrane. In New Hampshire it borders a tract of gneiss between II and III in Cheshire county; flanks the west border of the Hanover gneiss, and covers the Canaan synclinal in VI; and overlies gneiss in Surry, III, and Haverhill, VIII. There is a continuous range of it close to the Connecticut river, between Cornish and Haverhill. In fact, it is so constant next the older gneisses, that if it be clearly absent, the presence of a fault or of an unconformity may be assumed. In Vernon it encircles an area of gneiss, and the structure indicated is that of an overturned anticlinal. The rocks over the hornblende are the green schists formerly called talcose. This is proved upon I, III, IV in Vermont and the Connecticut river range about Cornish. Similar beds are associated with the green schists in Marlborough, II, and the Ammonoosuc goldfield. It seems more intimately connected with the green schists than with the gneiss, though often only the hornblende band will be present.

### HURONIAN.

This name is used as a matter of convenience to designate all the various schists of chloritic and argillitic aspect overlying the gneisses and inferior to the Cambrian, so far as known. The terranes in Vermont and western New Hampshire are the ones that have been studied the most, and are the most valuable for the determination of age, because more nearly related to the original Canadian exposures called by this name. The superiority of the main Huronian belt upon the east side of the Green Mountains to the gneiss is obvious upon every section

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from I to VIII. This view is confirmed upon II to V by the inferior position of the Halifax-Hartland range of gneiss.

The Connecticut river range is first seen in IV, and from thence to Maine and Canada upon every section it adjoins the hornblende schist or older gneisses, resting upon them. From VI to XI it is easy to connect the Green Mountain and Connecticut river ranges by a synclinal fold. Upon XII and XIII the direct connection is interrupted by granites and schists that seem to occupy the place of the Halifax-Hartland range, II to V. The apparently overlying position of the Huronian west of the calciferous in IX and XIII is due to inversion, as proved by the occurrence of the fossiliferous Helderberg in similar position just to the north of XIII in Canada (Lake Memphremagog). West of the Green Mountains the Huronian has its normal development in Canada and in the northernmost counties of Vermont, gradually diminishing in breadth southerly. It is not found south of VII. In southern New Hampshire the argillitic, quartzose, and micaceous divisions predominate nearly to the exclusion of the chloritic schists, which, with the characteristic dolomite, is seen in Raymond and Derry. Steatite occurs in it at Francestown in the ferruginous slates, and in the mica schists of Derry. All the schists referred to this series invariably overlie the gneisses.

### MONTALBAN.

So far the assignment of the formations to their proper order has been comparatively easy; but the introduction of the word *Montalban* immediately suggests discussion. Inasmuch as the typical locality, as shown by the name, lies within our territory, the relations of the group must be briefly discussed. The name of "White Mountain Series" was first employed by myself in 1869, as a matter of convenience, in the discrimination of the crystalline rocks of the White Mountain region and their extension into Massachusetts. Previously our geologists had usually regarded these crystalline schists as of Paleozoic age, probably Devonian. My studies in the Ammonoosuc district enabled me to advocate their pre-Silurian origin, and hence to give them a special name. It was not intended to describe them as a *system* separate from the Laurentian, though the conviction had been

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more than once stated in public that these rocks would probably prove to belong to a more recent series. This name was also applied with this original signification to the gneisses of central Massachusetts in Walling & Gray's Official Atlas in 1871.

A different use of the equivalent term *Montalban* was proposed by Dr. T. Sterry Hunt in 1870. It was applied to a somewhat similar series of schists overlying the Huronian, and expressly stated to include the rocks called Coös group and calciferous mica schists in our reports. In our belief, he has included under this designation rocks of different age,—the one a system below, and the other above, the Huronian. He has not yet given us any proofs of the later age of the Montalban derived from the study of the group in its typical locality along the presidential range of White Mountain summits, but the conclusions have been derived from general considerations, from several states, provinces, territories, and countries. There is a mica schist group later than the Huronian, which will be noticed presently; but our observations so far have led us to believe that the feldspathic mica-schist group of the White Mountains belongs to an older series, which might be called, as Prof. Kerr has named it in North Carolina, the upper Laurentian. I have examined the gneiss of Lake Winnipiseogee in company with Dr. Hunt, who pronounced it Montalban. As this lake gneiss has been shown above to be clearly older than the Huronian, and as it constitutes the axis of the Green Mountains, allowed by him to be thus ancient, it is obvious that the Montalban series, as defined by Hunt, embraces two groups of very different age. Hence the word has been used in two senses; but we invariably employ it in its original signification of pre-Huronian and post or upper Laurentian. The relative positions of the Montalban and Huronian have been sufficiently set forth in the New Hampshire report.* They do not often come into juxtaposition. The examples cited in this report are from the northern part of the state.

### MICA SCHISTS.

That there exists an enormous thickness of mica schist above all the rocks thus far described, especially in southern New

* Vol. II, p. 666.

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Hampshire, is unquestionable. No author who has devoted any attention to these groups has suggested an inferior position for them. They may be called Silurian, Cambrian, or pre-Cambrian, according as each author is inclined to regard New England very ancient, or on the verge of the Paleozoic. Such of the Rockingham group as is not referred to the Huronian belongs here, as shown in the Pack Monadnock Mountains (II), Belmont, Gilmanton, and Milton (V). It constitutes the substance of several interesting mountains, like the Pack Monadnock, Temple, and Lyndeborough, west of the Merrimack, and Catamount, Fort, Nottingham, Blue Hills, Blue Job, Hussey, Chesly, and Teneriffe, to the east. This orographic feature is paralleled in Mts. Monadnock, Kearsarge, and Ragged, of a possible older group carrying andalusite.

In the Connecticut valley there are 10,000 or 12,000 feet of mica schists and associated rocks. Many of them are characterized by the presence of staurolite and garnet, and by this feature are distinguished from a contiguous band of Cambrian clay slate. Its basal member is a quartzite, 1,000 feet thick in Cheshire and Grafton counties, and frequently occurring in immense masses, as in Croydon, Grantham, Moose, Cuba, and Piermont mountains. This rock resembles the Potsdam at the west base of the Green Mountains. In Washington county, Vermont, it may be replaced by a quartz schist, often micaceous. The calcareous member occupies a great many square miles in Vermont, amounting to more than one fourth of the entire area of that state. Logan regards the Canadian extension of this band as of Niagara, or upper Silurian, age. Dana supposes the fossils at Bernardston, Mass., to be so connected with this terrane that they determine its age—being upper Silurian or Devonian. There are many difficulties involved in readily referring this entire series to the upper Silurian; but if any collector will bring in fossils from characteristic localities proving its Niagara age, there will be nothing in our interpretation of its stratigraphy inconsistent with such a discovery. The rocks are evidently the newest of any of the great systems of strata described in our reports. To elevate them to the upper Silurian would not carry any higher the chloritic, silicious, or feldspathic schists already enumerated.



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A brief discussion of the stratigraphy of the Coös and calciferous mica schist groups will show why they take their high place in our system, and illustrate the nature of the difficulties encountered in understanding the various dips and overturns of the strata in our field. These groups are not separated in our sections, as they are supposed to be essentially the same series, and their lithological differences such as result from local causes. The calcareous division lies chiefly in Vermont, and on XI, XII, XIII, west of a granitic area. The most eastern of the micaceous areas upon XIII, and a part of the same in V, are calcareous; all the other schists of this age in New Hampshire lack the limestone. There is no foundation for the statement sometimes made, that the staurolite and andalusite crystals have been produced by the proximity of granite or other igneous rocks when erupted. On the contrary, these igneous rocks are common in the calcareous areas where silicates are rare, and are absent where these cruciform minerals are abundant.

The natural relations of the micaceous group and the neighboring series are displayed upon VI, VII, VIII. Four series of rocks are disposed in a synclinal form: the micaceous group is at the summit, underlaid first by clay slate, second by the Huronian, and third by gneiss. The synclinal is complex, as is to be expected where elevating forces have been so active. Upon VI there are nine, and upon VII there are seven, axes in the mica schist west of the Connecticut. So many groups in synclinal attitude must represent the natural order, and hence afford a basis for explaining apparent exceptions by overturns, faults, and unconformities. Upon the other sections some one or more of these four groups are wanting, but those present invariably sustain the same relations to one another.

The calcareous division is widest where the natural relations of the four groups are manifested. To the south of VI it has narrowed very much, and lies further east than the axis of the area northwards. This deflection has been occasioned by the elevation of the Halifax-Hartland range of gneiss, since it occupies the line of the central axis, and has its northern end environed by the mica schists, as shown on V. Repetitions of this gneiss, with the accompanying hornblende schist, are seen upon I and II, and there are others in Massachusetts. It would

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seem as if the clay slate and the Huronian were less constant than the mica schists and gneiss, since they do not appear along this range. The eastern band of the Huronian does not appear at all south of III, and its place over the gneiss may be taken by the hornblendic group. The absence of the clay slate alone is sufficient to enable us to assume the existence of an unconformity of the mica schist over the hornblende group. If the slates and Huronian were ever deposited over the Halifax-Hartland gneiss, they have been subsequently removed by elevation and denudation before the deposition of the mica schists.

An examination of the more northern sections shows that older or eruptive rocks take the place of the Halifax-Hartland gneiss of IX, XII, and XIII. Upon IX the granite has uplifted the adjoining strata, so that if our order of the groups were determined by their succession on this line, we would call the micaceous rocks older than the slates, and the Huronian newer than the slates. The intrusion of this immense mass of granite gave an unusual dip to the mica schists, and being of unyielding composition, the more flexible slates and chloritic schists were overturned upon both sides. The fundamental gneisses upon both sides seem to have been unaffected, except that they stand more nearly erect than before. Upon XII and XIII, the granite is larger in amount, and accompanied by gneiss and Huronian,—though scarcely shown upon the profiles,—and the overturns are less conspicuous. Just to the north of XIII the overturning of the Huronian is made more obvious by the presence of Helderberg fossils in strata dipping beneath it. The eruptive granites have penetrated fissures in the mica schists, so that the latter must be the oldest. Logan and the Vermont report regarded the granites as of Devonian age, because the disturbed rocks were thought to be upper Silurian.

It seems likely that these granites upon IX, XII, XIII, were connected with the uprising of the Halifax-Hartland gneiss in southern Vermont. If granite is derived from the fusion of schists, these bosses might have originated from the melting of rocks connected with that range deep down in the earth. Small areas of gneiss are connected with these granites upon the same axial line in the middle of the calciferous groups, and Selwyn finds them near the United States border in Canada, saying

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these "are apparently repetitions of the crystalline schists of the great Sutton mountain anticlinal to the north-west."* Granite also occurs there. The end of the gneiss range is connected with the granites upon IX, XII, and XIII by an anticlinal line, seen upon every intermediate section. Upon VIII, X, and XI this line is developed into a mountainous range, and the strata have very low dips. Thus the normal structure of this great basin is that of a synclinal, with an anticlinal in the middle more highly elevated than the sides, and sometimes bringing up the underlying gneiss. This feature is not confined to the calciferous group. Dozens of similar folds can readily be seen upon our chart; and the discovery of this type of structure aids materially in the understanding of the New England folds. Authors have pointed out a similar type of basin in the Appalachian region of Pennsylvania and Virginia, as instanced in Taylor's section across the coal measures near Nesquehoning, Penn.

There is great significance to be attached to the subordinate foldings of the calciferous group apart from this central line. In the middle of the area upon I, the underlying hornblende rock is brought up twice, and there are as many as five folds. Upon III the strata are entirely monoclinal, and separated by a band of clay slate and a fault from the non-calcareous division. Along White River, upon VII, but not delineated in our figure, we have discovered a horizontal fault in this group, and there must have been an extensive shoving westward of part of the series. The effects of the dislocation have not been observed outside of the formation, nor for a distance of more than 500 feet.

### THE ORIGIN OF GRANITE.

One of the subjects elucidated by the study of the New Hampshire rocks is the origin of granite. Owing to false theories, our predecessors have supposed it to have been derived from the semi-fusion of stratified rocks. Careful studies in the field, and the new methods of investigation with the microscope, are leading in the direction of purely igneous eruption. Two excellent illustrations are at hand, the one from Mt. Willard, and the other from Mt. Ascutney.

* *Geology of Canada*; report of progress for 1879–'80, page 5.

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### MT. WILLARD.

This mountain is nearly 3,000 feet above the sea, and nearly 1,000 feet above the Notch at the Crawford House. Most of it is composed of a hard mica schist or gneiss belonging to the Montalban series, and is the end of this rock as developed in the Presidential range. The mountains to the west of the Saco river consist of eruptive granites, which have been extruded and poured over this Montalban group. Two separate eruptions are noted at Mt. Willard. The first and oldest is termed Conway granite, or a coarse-grained rock with biotite for its mica. It once filled the whole valley of the Saco in the White Mountain region, and continues north-westerly through Mt. Willard and the Mts. Tom and Rosebrook ranges. The other is termed Albany granite, both these geographical names being derived from the adjacent towns, where they are admirably developed. This Albany granite seems to have been a purely igneous mass, coming up between the Conway on one side and a compact andalusite mica schist upon the other, termed the Kearsarge group, from its occurrence upon Mt. Kearsarge. The mica schist has been affected by the contact of a melted mass in such a way as to clearly prove that the Albany granite was eruptive. The peculiar effects of this intrusion are called "contact phenomena," and they have been produced only by the presence of a hot liquid adjacent to an earthy rock capable of alteration.

The Montalban rocks were terribly shattered before the protrusion of the Conway rock, and the fragments cemented by a fine-grained granite, which never passes into the former. The breccia thus formed is finely shown at the railroad house, a mile south from the Crawford House. A few hundred feet farther south, the Conway granite is well shown, but the contact between this and the Albany cannot be seen along the railroad. It is necessary to climb the steep south side of Mt. Willard to find the various series of rock altered by contact. The Conway granite, having once passed through the fire, is not altered, and therefore the changes to be described are altogether in the schists.

The Albany granite is characterized by the presence of crystals of feldspar so numerously scattered through the mass as to

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give it a spotted appearance, while the matrix is a grey, fine-granular aggregate of granitic minerals, somewhat resembling the mixture of pepper and salt. In our early reports this granite had been called "spotted," and also "trachytic," on account of these features.

When examined microscopically, the fine-grained mass shows quartz in formless grains, with fluidal inclusions, hornblende, biotite, magnetite, and apatite. Augite and fluor-spar are also frequent constituents. But the marked individuality is given by the uniform presence of well-crystallized, square prisms of zircon. Every sample of this rock from Mt. Willey, examined by Dr. Hawes, showed an abundance of zircons, which are white, clear, glassy, and sometimes yellowish. The large orthoclase feldspar crystals are known to mineralogists as Carlsbad twins.

This description represents the normal character of the granite; but both to the right and the left of the centre prominent differences manifest themselves, which are thus described by Dr. Hawes: "At a distance of one hundred feet from the contact, the crystals that form the granite have become smaller, with the exception of the large feldspar crystals, which are in consequence more conspicuous. At a distance of sixty feet a tendency in the quartz to assume crystalline forms is noticed, and the rock begins to appear porphyritic. At fifteen feet from the contact with the schists, the quartz is found in well defined dihexagonal pyramids as large as peas, and these with the Carlsbad twins of orthoclase are imbedded in a ground mass no longer resolvable by the unaided eye or lens. Upon the contact the ground mass is nearly black in color, flinty in texture, and apparently homogeneous. The Albany granite has become a quartz porphyry.

"The accompanying microscopic changes are as striking. Approaching the contact there is a continual diminution in the amount of the hornblende and the size of its crystals. There is a corresponding increase in the amount of the biotite, which finally entirely replaces the hornblende. These biotite crystals are at first quite large, but they diminish rapidly in size near the contact, and upon the contact are reduced to a dust. The ground mass which makes its appearance between the quartz and orthoclase crystals grows firm, but upon the contact,

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though of extreme fineness, it is still entirely crystalline. In this ground mass all the minerals of the granite found in specimens distant from the contact are recognizable, but near the contact no individual crystals can be determined. In this series of changes all the minerals have taken part except the twin feldspars and the zircons.

"These modifications, which are repeated in a less conspicuous manner upon approaching the contact with the granite upon the opposite side of the mass, are such as might be induced in a molten eruptive mass, which like modern lavas contained some crystals already found at the time of eruption by the effect of contact with cold walls, the hydrous nature of one and the anhydrous nature of the other being factors modifying the extent of the effect."

The schists of the Kearsarge group consist of quartz, muscovite and chlorite, with many layers filled with beautiful pencils of andalusite. Unimportant accessories are biotite, titanic iron partially decomposed into leucoxene, magnetite, and tourmaline. No marked change is visible in it at the distance of fifty feet from the line of contact. At twenty-five feet the schists are more definitely and coarsely crystalline, biotite becomes more prominent, and tourmaline crystals have become very common. At fifteen feet the rocks are still schistose, but much fractured, and full of shining dots that indicate a new crystallization. Here the rock is a mica schist. The chlorite decreases, and biotite and tourmaline increase. Between this point and the contact the schist loses entirely its structure, and is altered into a black hornstone, breaking into smaller angular fragments. Ten feet from the schists a qualitative reaction for boric acid can be obtained.

Last of all is a well defined zone, or a dark gray mass filled with reticulated black veins. Scarcely noticeable at the top of the mountain, it becomes wide and prominent below. The veins divide and subdivide, giving to the whole a fused, slaggy appearance. Microscopically it is found to be a nearly pure mixture of tourmaline and quartz.

Just between the tourmaline veinstone and Albany granite is a breccia, called the "mixed zone" by Dr. Hawes, varying from one to twenty feet wide upon Mt. Willard, but known to

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be much wider elsewhere, as upon Mt. Tom. It consists of fragments of various schists, pieces of a foreign quartz porphyry, all connected by the granitic material. The feldspar crystals are all broken to fragments, and the whole mass is impregnated with tourmaline.

Summarized, these zones may be thus stated: 1. Zone of the argillitic mica chloritic schist, containing by actual analysis from 36 to 39 per cent. of quartz, 44 to 49 per cent. of muscovite, no biotite, 8 to 13 per cent. of chlorite, 2 per cent. each of titanic and magnetic iron, and no tourmaline. 2. Zone of the biotitic mica schist, containing 45 per cent. of quartz, 43 of both micas, 6 of chlorite, and 3 of the iron oxyds. 3. Zone of the tourmaline hornstone, containing 50 per cent. of quartz, 29 of the micas, no chlorite, 4 of the iron oxyds, 15 of tourmaline. 4. Zone of the tourmaline veinstone, containing 50 per cent. of quartz, no mica or chlorite, 3 per cent. of iron oxyds, and 46 of tourmaline. 5. Zone of the mixed schists and granite. 6. Zone of the granite porphyry, biotitic. 7. Zone of the Albany hornblendic granite.

There seems to be a systematic and progressive series of changes in the schists. First, water has been removed; second, boric acid and silica have been added; third, alkalies have been added directly upon the contact. These additions and changes are such as would come from igneous eruptions, and therefore the inference is authorized that the Albany granite was eruptive like lava. The inclusion of varied products in the mixed zone indicates the movement of a fluid mass no inconsiderable distance through fissures. Very hot vapors must have accompanied the eruption.

Such is a brief summary of the paper of the late Dr. Hawes, formerly assistant upon the Geological Survey of New Hampshire, published in the *American Journal of Science and Arts*, in January, 1881.

### MT. ASCUTNEY GRANITE.

Upon V we have delineated two peaks of granite or syenite known as Mt. Ascutney and Little Ascutney. The igneous rock seems to have been erupted from below through one or more

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vents and spread over the rock adjacent, very much in the manner of modern lava.

The summit of Ascutney lies near the south-east corner of Windsor, but portions of the mass are situated in the towns of West Windsor and Weathersfield. If the two mountains were just alike, the granitic area, when protracted upon a map, would resemble a pair of spectacles;—as it is, the eastern higher area is four and a half miles long, two and one eighth wide, and the summit 3,186 feet above sea level, while the base of the cone is 1,200 feet above the sea. The western area is nearly circular, a mile and one fourth in diameter, and 1,700 feet above the sea. The rock is often a hornblende granite—mica not being excluded—and the variety called *granitell* by Dr. Hawes, containing neither of the accessory minerals, is abundant in irregular patches in every part of the cones. Brecciated masses composed of the underlying stratified rocks are plentiful upon the west side of the larger mass and upon the smaller mountain, insomuch that one can easily believe portions of the granite have been made from the melting down of the fragments. The major axis of the "spectacles is six and one half miles long, at right angles to the course of the strata. Two stratified groups underlie the unstratified area. Most of the eastern cone is located upon the calciferous mica schist. The rest of it, and the smaller cone, rests upon gneiss. The gneiss underlies the mica schist at the same angle of dip, and we do not yet discover any stratigraphical axes in the latter. The relations of all these rocks appear upon section V. This granite seems to occupy a position similar to that of the gneissic anticlinals in Guilford, I, and Brattleboro', II, or Black Mountain in Dummerston.

There is no evidence of elevation of the schists, in consequence of a disturbance, when the igneous mass came up. The same local variations appear upon the south that are visible at the north sides of the mountains. The mica schists manifest the presence of heat for a distance of 500 feet or more from the granite. The slates have been indurated so that they ring like iron when struck by a hammer. The limestones are sometimes calcined, and even glazed. Veins enter both the rocks from the granite for several yards distance. The gneiss is not altered at the contact line. It would seem, therefore, as if we had here

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examples of contact-phenomena, and only the later strata are affected, because the gneiss had already been made crystalline before the eruption of the granite.

The adjacent hill-tops of the mica schist country are approximately 1,200 feet above the sea, which corresponds with the elevation of the base of the granite. On entering the valleys of erosion at the base of the granite, where small streams have removed considerable rock, it is discovered that the schists run under the igneous rock, certainly for 300 feet. Were a tunnel driven through the mountain, as through the celebrated Kammerburg of Bohemia, similar phenomena would be found;—below a certain horizon—say 1,200 feet—only the schists would be cut through, excepting the central plug of granite. The cone of granite has its base upon the floor of schists, while its height is about 2,000 feet. It is to be regarded as an overflow of igneous matter upon the common rock of the neighborhood, and where it comes in contact with clayey layers they were baked; and where limestones were heated, the result was calcination, induration, and glazing. Upon this view it is easy to understand why there should be an indurated belt about 500 feet in width enveloping the cone. The heated mass covered the surrounding country just so far, and that outer shell has since been removed by denudation.

My father, in the Geological Report of Vermont, advocated the doctrine of the derivation of the granite from below, but supposed the cone continued to enlarge below the surface, and, as he conceived of it as a liquid, suggested its enclosure by walls of schist which have subsequently been removed by erosion. The prevailing modern view of the origin of granite is like this, except that it demands a greater degree of erosion. Says Prof. J. W. Judd, in his work on volcanoes, 1881, p. 252,—"The plutonic rocks, as we have already seen, exhibit sufficient proofs in their highly crystalline character, and in their cavities containing water, liquefied carbonic acid, and other volatile substances, that they must have been formed by the very slow consolidation of igneous materials under enormous pressure. Great pressures, it is evident, could only exist at great depths beneath the earth's surface. Mr. Sorby and others have endeavored to calculate what was the actual thickness of rock under which

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certain granites must have been formed, by measuring the amount of contraction in the liquids which have been imprisoned in the crystals of these rocks. The conclusions arrived at are of a sufficiently startling character. It is inferred that the granites which have been thus examined must have consolidated at depths varying from 30,000 to 80,000 feet beneath the earth's surface," etc.

If Ascutney were the only granite mountain in New England, it might be easy to imagine an erosion of from 20,000 to 70,000 feet from around it; but what is true of this mountain must have been true of all New England and of the whole crystalline area of the Atlantic coast. A tract of country, say 1,000 miles long and 300 miles wide, according to this view, has been covered by rock from four to fourteen miles in thickness, which has been transported by streams of water oceanward. If that were true, then our Atlantic coast line would have been several hundred miles nearer the old world than it is now.

Such extreme views are entirely unnecessary. Two other agencies may be called upon, besides the weight of overlying rock—lateral pressure and elastic vapor held in confinement. Or, if it be necessary to believe that the liquids condensed so far below the surface, the igneous mass may have flowed through fissures without losing its inclusions, and kept them intact till within a few hundred feet of the light. If slides prepared for the microscope can hold drops of liquid carbonic acid restrained by the twentieth part of an inch of rock-wall, why could not several hundred feet of pasty cooling lava be equally effectual? At the surface the inclusions must have escaped into the atmosphere just as, upon stream sof modern lava, steam and vapors boil and disappear. After solidification, all these imprisoned vapors are firmly enclosed whether within ten feet or ten miles of rock. The original surface, now denuded, may have been a genuine lava. Some modern lavas, like granites, contain inclusions of condensed gases, and present many of the phenomena characteristic of the older rock; yet no one supposes that five or ten miles of rock has been removed from above them. The conditions of modern aqueo-igneous lava fusion are not very different from those invoked for the origin of granite.

It is easy to name other mountains of granite and porphyry,

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which so resemble Ascutney as to make one believe they will present evidences of a similar origin. Such may be found upon our sections,—as Moose Mountain near the east end of V; Green Mountain, Effingham, and the Ossipee Mountains in VI; Pequawket in VIII; and Star King, near Jefferson, in IX. There are many others in the White Mountains.

Another class of volcanic ejections, probably older than the granites of the White Mountains, are largely developed upon sections XI to XIII in Vermont. The rocks are referred to the Huronian in our descriptions, and consist of stratified diabases, protogenes, epidotic and chloritic schists, fine-grained quartzites, etc. It is supposed they may have been metamorphosed from volcanic ashes and scoriæ. Some of the mountains exhibit dome-shaped features, and therefore resemble volcanic piles much degraded. Selwyn calls the extension of these rocks into Canada the "Volcanic group," and was the first person to call attention to their resemblance to rocks of igneous origin in Great Britain and Australia. These views will commend themselves to those who are familiar with the lithological character of igneous rocks.

### EARLY HISTORY OF THE CONTINENT.

In the geology of New Hampshire I have shown how the dry land of the state has been gradually reclaimed from the primitive ocean, and that the earliest islands can now be recognized in the several porphyritic gneiss areas. I have lately gone further, and argued that these same areas, with others like them, represented the first dry land of the whole American continent. It is claimed that they were of eruptive origin, very much like submarine volcanoes, and that they gradually gathered sediment from the wash of the hills, and increased in size on account of general continental elevation. Some of the conclusions were suggested by a personal study of the Hawaiian islands. A few of the considerations favoring our theory will now be presented.

1. Considering the igneous origin of the earth, volcanic energies would naturally continue their action as soon as there was a crust to be broken through, and immense piles of melted rock would ooze from the numerous fissures. Up to Laurentian times all admit the universality of igneous outflow, while but few

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have ventured to speak of anything like volcanic action, except as it has been manifested in the formation of dikes in these early periods. There has been a tendency to class the ancient granites and porphyries with rocks of sedimentary origin, and consequently to restrict the action of igneous agencies to phenomena of slight importance. Several English writers, and, in our country, Dr. Selwyn, of Canada, have been calling our attention to the existence of a volcanic group in later Huronian or early Cambrian times. These are the rocks so largely developed about Lake Superior, New England, and the Province of Quebec, consisting of stratified schists, diorites, diabases, amygdaloids, and felsites, identical in composition with true eruptive masses of the same name. Investigation shows that oftentimes these schists are disposed like the lavas ejected from one series of volcanic vents. Suppose, for example, that Etna or Vesuvius should become extinct: in the course of ages the rains would obliterate the craters, and reduce the lavas to a rounded dome of greater or less regularity. We should recognize the volcanic origin of the mountain in the absence of craters, from the lithological similarity of the rocks to those known to have been melted and ejected from vents, while the disposal of the material in a conical attitude shows us that it might once have been protruded from below. So we find in our Eastern country many domes of diabasic or protogenic schists, whose volcanic origin may be predicated, both from their lithological character and physical aspect.

Now this volcanic group of Huronian times indicates the existence of a greater degree of igneous activity than has been described for the palezoic ages, even in Great Britain; and consequently this is an indication pointing significantly towards the predominance of thermal influences in the still earlier periods. In the Laurentian age the fires should have been yet more vigorous, because the time of universal igneous fluidity was less remote.

2. A careful study of the crystalline rocks of the Atlantic slope indicates the presence of scattered ovoidal areas of Laurentian gneisses. Those best known have been described in the Geology of New Hampshire. Instead of a few large synclinal troughs filled to great depths with sediments, the oldest group

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is disposed in no less than twenty-two areas of small size, scattered like the islands in an archipelago. In a chapter upon the physical history of the state, I have proposed the theory that the earliest land within its limits consisted of this series of islands, not packed together as closely as now, in an area of perhaps three thousand five hundred square miles, but as much more widely separated as would be determined by smoothing out the various anticlinals and synclinals that were formed later. By reference to our maps in Maine, Massachusetts, New Jersey, Pennsylvania, Virginia, North Carolina, and Georgia, many similar ovoidal Laurentian areas may be specified, usually larger than those of New Hampshire. This may be due partly to a less thorough knowledge of the exact areas occupied by this older gneiss, and partly to the existence of a greater number of volcanic vents, giving rise to a more widely spread and thicker mass of ejected material. Over the Atlantic slope and Canadian highlands these primeval islands have, in later periods, been cemented together by a subsequent deposition of material; but in Missouri, Arkansas, and Texas we recognize, even now, these early islands.

3. The lithology of the Laurentian and other crystalline rocks is very like that of igneous ejections. We now divide the Laurentian into three parts. First and lowest is the porphyritic gneiss of New Hampshire corresponding to Selwyn's proposed restric tion of the whole series to "all those clearly lower, unconform able, granitoid, or syenitic gneisses in which we never find interstratified bands of calcareous, argillaceous, arenaceous, and conglomeratic rocks." Next will follow the Hastings and Grenville series, and all the schists containing the Eozoon, as well as the Bethlehem, Lake Winnipiseogee, and Montalban groups of the Atlantic slope. Third, will follow the Montalban; while the Labrador or Norian series, sometimes called Upper Laurentian, is rejected since it is an igneous rock, not stratified. The lower Laurentian is azoic, the other groups eozoic; and unless newer distinctions are to be made hereafter, it looks as if we might claim these various azoic Laurentian islands as the first-formed dry land, as they certainly are the nuclei of the existing continents.

There are no minerals in these Laurentian islands that do not

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occur in eruptive granite; and the schistose structure is often so faint that the field geologist need not be blamed if he acknowledges his inability to detect it. Likewise we discover the same fluidal inclusions and the vacuoles that pertain to granite. If we should follow Sorby and Clifton Ward in saying that granite has been formed beneath a pressure equivalent to a weight of forty thousand feet of strata, the same must be said of the early gneisses. With this general assertion of the identity of gneiss and eruptive granite we must be satisfied at present, without entering into detail.

4. The analogy of the origin of oceanic islands at the present day suggests the igneous derivation of the Laurentian areas. Most of the high islands of the Pacific are composed of lava, with the volcanoes frequently in action.

The so-called lowlands are likewise of volcanic origin,—since coral polyps have built up reefs upon the igneous area after the disappearance of the fire, and the Hawaiian areas are encircled by reefs. After the volcanoes have become cold, loose material would be worked in between them, coral reefs would grow, and in various ways the land area would be enlarged, and finally an archipelago may become a large island. It needs only time and a repetition of these constructive agencies to make a continent out of a series of archipelagoes.

5. The oceanic volcanic islands are not inferior in size to the crystalline Laurentian areas upon the present continents. Hawaii, of the Hawaiian group, may illustrate their position and shape. Its area above the water-line is 4,210 square miles, and its cubical contents above the sea-level are about the same with those of New Hampshire. It rises from a plateau over 16,000 feet deep, thus forming a cone 30,000 feet high, whose cubical contents must be twenty times greater than the portion making dry land. The length of the entire series of islands, all of similar character, is 350 miles, and the area of the base of the lava must be about 100,000 square miles. These cones have been built up by the accumulation of lava ejected from the interior of the earth, and they are entirely isolated, the nearest land being one thousand miles distant. The ground-plan of this volcanic mass is that of two elliptical areas, either of which is like some of our Laurentian islands, and is certainly as large

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as any of these ancient lands south of the St. Lawrence. The land area of the Hawaiian islands is less than that of Massachusetts, but their base must be equal to the whole of New England and New York combined. Surely it cannot be avowed that volcanic areas are too small to be compared with the space occupied by our oldest formation.

## THICKNESS OF THE FORMATIONS.

For a thousand further details the reader is referred to the published and manuscript sections and catalogue, accessible to all inquirers at the Museum. I will close by adding a list of the several formations of New Hampshire and Vermont in their supposed natural order, with their estimated thickness:

| | FEET. |
|---|---|
| Devonian Helderberg, near Memphremagog lake, | 200 |
| Niagara group, at Littleton, etc., | 500 |
| **CHAMPLAIN VALLEY.** | |
| Loraine slate, | 400 |
| Hydro-mica schist (Taconic range), | 2,000 |
| Trenton limestone, | 400 to 600 |
| Black river and Birdseye limestone, | 40 |
| Chazy limestone, | 400 |
| Levis limestone, | 600 |
| Upper calciferous sandrock, | 200 |
| Lower " " | 400 |
| Fucoidal layer, | 200 |
| Potsdam sandstone, red, 500 | |
| " " gray, 310 | |
| " " quartzite, 1,200 | 1,200 |
| Georgia slates, | 3,000 |
| Cambrian slates and schists, | 4,000 |
| Total of Champlain Valley, | 13,740 |
| **CRYSTALLINE GROUPS.** | |
| Calciferous mica schist and Coös group, | 12,000 |
| Kearsarge group, | 1,300 |
| Rockingham mica schist, | 6,000 |

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| | |
|---|---|
| Merrimack group, | 4,300 |
| Huronian, | 12,000 |
| Hornblende schist, | 1,500 |
| Upper Laurentian, Montalban, | 10,000 |
| Middle Laurentian, Lake Winnipiseogee (Green Mountain) gneiss, | 18,600 |
| Middle Laurentian, Bethlehem gneiss, | 6,300 |
| Lower Laurentian, Porphyritic gneiss, | 5,000 |
| Total crystalline, | 77,000 |
| Grand total, | 90,740 |



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# AGRICULTURAL EDUCATION HISTORICALLY CONSIDERED.

BY PROF. C. W. SCOTT, OF THE N. H. COLLEGE OF AGRICULTURE AND MECHANIC ARTS.

[Originally read before the State Board of Agriculture, at Manchester, and subsequently before the State Grange, at Weirs.]

It is a long step from the scholastic education of the Middle Ages to the practical education attempted in the scientific and technical schools of to-day; but it is natural that the rebellion against the former should end in the establishment of the latter. Bacon himself probably never had a conception of such a result, yet it has been the logical outcome of his philosophy. Since that philosophy produced an entire series of new sciences, his disciples could not consistently do otherwise than introduce these sciences in their plan of education, even at the expense of the studies most honored by Bacon himself. To the oft-repeated assertion, that he tried to make thought practical, may be added the other assertion, that this century threatens to exclude from education everything but the practical.

In carrying out the plans for practical education, scientific and technical schools have been founded, apparently with very modest intentions, and have then been pushed into positions which sometimes must seem as surprising to their founders as to their competitors.

At first thought, it would seem that a training for a special occupation would never enter the plane of a liberal education in a college with a long-established course. Perhaps that would

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be true in a society with fixed social layers: it is not true in America. The two classes of graduates have been brought into constant competition. The technical student is thus influenced in a twofold way: First, he demands a wider scope in his studies; and next, he demands equality between his school, which counts its age in months, and the old colleges which are the growth of years. His own success in life is perhaps his most convincing argument. As a result, all schools of this class have rapidly advanced in position and influence, forming a series in which the agricultural college comes last in time and development.

The first of the polytechnic schools appeared in France, during the years which followed the great revolution. After France followed Austria, Switzerland, and Germany, and by the middle of the present century there was through Europe a chain of strong scientific schools, provided generally with costly appliances, and always supported by government patronage.

The first scientific school in America was probably the military academy established at West Point in 1802. Though a military school, its graduates, as explorers, engineers, and scientific men, have gained reputation in the peaceful walks of life, quite as much as on the battle-field. Among the graduates of the class of 1806 was Capt. Alden Partridge, a man who was remarkable for his ability and energy, and exerted a marked influence in shaping the scientific education of New England. He became an instructor at West Point, and was for a short time commander. In 1820 he established a military academy at Norwich, Vt., and afterwards similar schools in several other states. The Norwich academy, after some changes, developed into Norwich University, which seems entitled to claim the honor of being, next to West Point, the oldest of all the scientific schools of the country.

In Europe, the year 1799 saw the founding of three agricultural schools,—one in Austria, one in Prussia, and a third in Switzerland; and several years after, others were established in Austria. But in America there had been no recognition of the claims of agriculture upon the schools, when, in 1826, at Troy, N. Y., the Rensselaer Polytechnic Institute was established. The school was named from the patron who furnished the means for starting it; but the real founder was Amos Eaton, who was first

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at the head of the institution. This was the first school of science not on a military basis, and its object was stated to be "The application of science to the common purposes of life, and especially to the qualification of teachers to instruct in the application of chemistry and natural history to agriculture, domestic economy, and the arts and manufactures." During the next quarter of a century the scientific influence took hold of the leading colleges of New England. In 1847 there was an endowment for the Lawrence Scientific School at Harvard; and at Yale, in the same year, an agricultural chemist (John P. Norton) made a beginning for a school which, when endowed, several years later, became the Sheffield Scientific School. During this time a similar endowment for a scientific school had been received at Dartmouth college.

The half century from 1825 to 1875 was a period of growth such as would naturally give prominence to scientific or technical schools. The development of new territories gave opportunities for graduates to coin practical information into dollars. Public works and great systems of railroads were constantly turning young graduates into civil engineers. While professional students left the college to begin a long and expensive course of study, many graduates of scientific schools, which gave less mental discipline, were stepping directly into positions which offered fair pay and flattering prospects. This condition of things gave the scientific schools a strong leaning towards engineering. The tendency is well illustrated by the institution at Troy, N. Y., which dropped all thought of agriculture, or its applications, and became one of the most technical and most successful of engineering schools.

These years also saw a rapid development of agricultural interests, and a corresponding increase of agricultural wealth. Cheaper transportation increased the value of the product of the farm; new mechanical appliances decreased the drudgery of farming. From 1850 to 1870 the value of farming implements in the country more than doubled; agricultural chemistry was being developed; other sciences, themselves new, were being pressed into the service; and agriculture was being slowly pushed towards the position of a science. There were new questions to be considered about commercial fertilizers and animal nutri-

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tion, while irrigation and drainage, stock-breeding and dairying, were coming to be considered in a new light.

In every new demand for educational facilities, there were to be considered the agricultural societies reckoned by hundreds, the agricultural papers which numbered nearly a hundred, and their readers who had to be reckoned by the hundred thousand. Hence, with the general demand for practical education was joined a special demand for an education adapted to the needs of farming communities, and directly or indirectly putting dollars into the pocket of the farmer. To establish a system of schools for these purposes, in the manner in which other colleges had been established, by the munificence of individuals, would be the work of centuries. The advocates of these institutions would see them spring forth and bear fruit in a decade or two; so they turned to the national government for help to establish them. For this there was sufficient precedent: the principle of granting lands of the public for educational purposes is older than the constitution itself, and dates back as far as 1787, when a sale of land in south-eastern Ohio was made to the New England Ohio Company. At that time two entire townships were set apart for the purposes of a university.* In 1794 there was another grant to Ohio for educational purposes, and by 1821 nine other states had received aid of this kind. Before the latter date, and for years after, there were discussions over the claims of the older states, and repeated attempts to induce congress to recognize these claims, and put all the states upon the same basis. As agricultural education came to be discussed, its claims were united with those of practical education, the former being considered one of the important branches included in the scheme of the latter. The movement gathered force in the West, and Illinois seemed to be the leader. At a meeting called in that state, in 1851, to discuss the question of a different kind of education, two resolutions fairly expressed the demand. One resolution expressed the following: "That as the representatives of the industrial classes, including the cultivators of the soil, artisans, mechanics, and merchants, we desire the same privileges and advantages for ourselves, our fellows, and our posterity, in each of our sev-

* *Ten Brook's State Universities*, p. 66 and following.

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eral pursuits and callings, as our professional brethren enjoy in theirs." *

In a second resolution it was asserted that the wants of these classes could not be met by the institutions designed to meet the wants of the professional classes. In 1852 there was a second convention at Springfield, and a third at Chicago, and a league was formed and a resolution adopted to memorialize congress to make a grant of lands to establish and endow industrial colleges in every state in the Union. In a fourth convention, in 1853, a memorial to the legislature was prepared. In it the petitioners assert that they need the same application of knowledge to their pursuits which the learned professions enjoy. They inquire what kind of military commanders the classical colleges can make, and then assert that these colleges are as well fitted to supply the place of West Point as to meet the demands of farmers and mechanics. They show, taking the country together, that only one two-hundredth of the population are in professional occupations; they assert that more than two hundred colleges and schools of high standing are devoted wholly to the interests of the professional classes, while there is not one "with a liberal endowment designed for the liberal and practical education of the industrial classes."

In the same spirit the legislature passed a series of resolutions, and gave instructions to the representatives in congress, directing them to use their influence to secure an appropriation of land to be used in founding industrial universities, as the resolution says, "for the more liberal and practical education of the industrial classes and their teachers."

Illinois invited the other states to unite in the work, and almost at the same time with this movement was one in the same direction in the Eastern states. The *New York Tribune* had many kind words to say in favor of the plan. The governor of New York endorsed it in an annual message, and recommended a state college planned to unite instruction in agriculture and in the mechanical sciences. In Massachusetts, Hon. Marshall P. Wilder recommended the movement; and President Hitchcock, of Amherst college, had advocated the principle as early

* See article on agricultural education in *American Encyclopædia of Agriculture*, which has been freely used in writing the early history of the movement.

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as 1851, before the Massachusetts Board of Agriculture. In 1853 there was a convention at Albany, N. Y., to discuss the subject and settle on some plan of action; and for several years it was kept before the public, being advocated by influential papers, and endorsed by leading men. In a few states agricultural schools or colleges were organized. The first of these schools is said to have been at Cleveland, Ohio, in 1855. Whatever success it met with was not noised abroad, for it soon fell from sight, and the literature of agriculture is singularly silent in regard to its history. Quite different from this has been the history of the Michigan college, which commenced its real work about 1857, and that of the institution in Pennsylvania, and also of another in Maryland. These latter two colleges opened their doors in 1859. As these schools have been greatly modified by the U. S. act of 1862, their history is best detailed in connection with the system of national colleges.

During the few years before 1857, several bills on the subject of practical and scientific education were brought before the national congress. And one, introduced into the house of representatives by Mr. Morrill, of Vermont, was nearly successful. From the first it met with the greatest opposition from the Southern members, who were too intent on introducing slave labor into the territories to think of tolerating industrial education in the states. As Mr. Morrill was chairman of the committee on education, and a Southern man was chairman of the committee on public lands, the bill was referred to the latter committee, where it was kept back as long as was possible, and then produced with an adverse report. Then came a discussion in the house, and another in the senate where it was strongly opposed by Jefferson Davis and others, and finally passed by a majority of two. More than two years had passed since the introduction of the bill, and it was immediately vetoed by President Buchanan. In June, 1862, while most of the opposition were employed south of the Potomac, the bill was again brought before congress. It passed both branches by a vote that was four to one in its favor, and was immediately approved by President Lincoln.

The provisions of the bill were simple in their nature, and easy to be enforced. First, it provided for at least one institu-

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tion in each state, and gave, as an endowment, land to the amount of thirty thousand acres for each member of congress. Next, it provided for an annual report to be sent by each college to every other college in the system, and made each state forever responsible for the money received from the sale of its share of the land. This money was to be an instruction fund, and the state must guarantee at least five per cent. interest upon it. Finally, nothing could be much more liberal than the scope of these institutions. The bill says of these colleges, "Their leading object shall be—without excluding other scientific and classical studies, and including military tactics—to teach such branches of learning as are related to agriculture and the mechanic arts, in order to promote the liberal and practical education of the industrial classes in the several pursuits and professions in life."

It had taken hardly more than a decade to bring about the foundation of these colleges, and a friend of the movement might think that the hardest part of the work had been done: in reality it had been but begun. The succeeding twenty years were destined to be full of trials and misunderstandings and disappointments.

Any one carefully considering the law of 1862, and the history of the movement which produced it, must understand the broad basis on which the colleges were built. The law was part of a great movement for scientific and practical education—a movement that had begun before these colleges were organized, and has been materially helped by them. In 1860 there may have been twenty institutions that recognized other than classical methods of training; now there are nearly ten times that number, and they are yearly granting degrees to about twelve hundred students.

These national colleges, however, came to be known as agricultural colleges, and with that name came one of their great troubles. A considerable portion of the community fell into the opinion that these institutions had been established for only one purpose, and proceeded to judge them exclusively from the standard of their agricultural instruction. The excellence of work in other directions was entirely disregarded, and in some cases was made the ground for systematic depreciation and con-

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demnation. However unjust any such opinion may be, it can not be questioned as a matter of history that it has existed to an extent sufficient to prevent some of the colleges from doing a very high grade of agricultural work. In some farming communities the distrust has proceeded so far, that those who would naturally be the patrons of agricultural instruction have stood aloof and awaited results. Worse than demanding bricks without straw, they have withheld the clay also, and have been waiting for institutions without agricultural students to produce farmer graduates.

Of course there are two views which may be presented. There may have been farmers who had extravagant expectations—who looked upon agricultural professors as magicians having the ability to transfer their power to their students, so that a graduate of an agricultural college, like the witch-hazel-using finder of hidden fountains, would go about turning worn-out acres into productive meadows, and thistle patches into waving fields of grain.

There were certainly others who believed neither in agricultural education, nor in very much education of any kind, for farmers, and so had the easy task of condemning everything connected with the subject because it was not something else.

On the other hand, there were few men fitted to give agricultural instruction. There were still fewer works suitable for text-books, and systems of agricultural lectures either have in them the work of years, or are worse than useless in a college. In some cases the national colleges fell into the hands of men who had little understanding of the ends to be aimed at and the classes to be benefited, and they constructed courses of study agricultural in nothing but the name. Instead of horticulture, they suggested Greek roots, and having put a little natural history in the place of some of the classics, depended upon agricultural chemistry to cover a multitude of deficiencies.

The difficulty in this part of the college work was further increased by the fact that there was no recognized standard of work before the public. Patrons knew not what they would demand, and friends, directors, and instructors were in doubt as to methods, and frequently were compelled to appear inconsistent.

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Despite all these difficulties, nearly every college that has persistently attempted to do good work in agriculture has met with fair success, while some have met with the most marked success. Most of them are better fitted than ever before to do good work, and offer great possibilities for the future.

When the states came to make use of the proceeds of the national appropriation, several methods were followed. The easiest way for the state was to turn over the fund to some existing institution, which only in a few cases could be an agricultural college, and to require it to add an agricultural course if it gave scientific instruction, and several scientific courses if it gave only literary instruction. By this method the state incurred no expense, took little responsibility, and reserved all rights of grumbling.

The states that had no agricultural colleges and followed this method can be put into one class, and the other states can be put into four classes, although the misleading titles of colleges, the absence of full information, and the uncertainty of many of the statistics, make the limits of division somewhat uncertain, and take much from the accuracy of the conclusions.

In the first class are three New England states (Connecticut, Rhode Island, and Vermont), two Middle states (Delaware and New Jersey), six Southern states (Kentucky, Louisiana, Missouri, Mississippi, North Carolina, and Tennessee), and the Western states Minnesota and Oregon.

Of the colleges thus endowed in the New England states, two, at least, have done excellent work upon subjects within the scope of the national act, and one has been especially marked for its good work in agricultural chemistry; but agricultural students have been curiosities in all three of the states, for the three colleges together have probably not graduated three such students during the last fifteen years.

In New Jersey it appears, from the occupations of ninety-nine of the scientific graduates from 1869 to 1881, that 6 per cent. are connected with agriculture, and 41 per cent. with engineering. If the per cent. of scientific students taking the agricultural course is twice as large as is indicated by this, there is one agricultural student for each 200,000 of the population of the state.

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In Missouri the national appropriation turned the state university into an institution with twelve courses,—under-graduate and post-graduate. Between 1869 and 1881 five degrees in agriculture were granted. The arrangement of the courses is such that this gives no measure of the number of students who take an agricultural course or one or more studies of that class. Including all these, the result is one agricultural student to 27,000 inhabitants. This branch of the university work is being energetically pushed, with a decided tendency toward a short course, with only elementary requirements for admission.

In Tennessee, East Tennessee University was changed into Tennessee University, which offers eight courses of study. Between 1871 and 1880 it granted 91 degrees, and during the latter year had eight students in the agricultural course.

Kentucky and Mississippi each organized a new department in the state university, but each, in 1878, detached this department and organized a separate college. In Mississippi the new college opened its doors in the fall of 1880, and enrolled during the first year eighty-seven students in the regular course, and a much larger number in the preparatory course. It calls itself an agricultural and mechanical college, but at present has only a single course.

The officers of the college call attention to the fact, that during several years, while there was a connection with the state university, there was not a student taking the agricultural course, while a period of less than three years of separate existence has been sufficient to put one hundred and fifty students into the regular course, and a larger number into the preparatory department. It claims the third place among colleges in the number of agricultural students.

There is another college in the state doing work for colored students, but this institution alone, if it is doing real agricultural work, has at least one student for each seventy-five hundred of the population.

As a rule, all the old colleges that have received any part of the national appropriation have done better work in the old ruts, but they have not learned how to attract agricultural students. Having established the new courses, they have waited for men to study them, but the students that have come have generally

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been drawn into fields not agricultural. These colleges have been subjected to sharp criticisms, and every objection has made it more difficult for them to do the work demanded. Of several it may be said that no agricultural students have ever been graduated.

A second plan for establishing the new college was to place it beside an existing institution, but to keep funds and students distinct. The advantages urged are evident,—libraries, museums, instructors at nominal prices, and the reputation presumably gained. On the other hand, there has been an unfortunate current belief that agricultural students so situated are subjected to petty insults, that new institutions are overshadowed by the old, and unnoticed by those who bestow their money upon colleges, and that they are frowned upon if they show too much inclination to grow. It is quite certain that no college situated thus can teach agriculture successfully if destitute of two conditions. It may use instruction from the older college, but it must have an independent faculty, who are thoroughly in sympathy with the work, and it must give an education upon a basis sufficiently broad to give its students an assured position. Apparently New Hampshire is the only state that organized a college in this manner, and the fund upon which it was established was smaller than that of any other college established upon its own funds. This college has graduated, from 1871 to 1883, eighty-five students, one third of whom are connected with agriculture, and, leaving out those taking other courses, it has one agricultural student for 13,000 inhabitants, a ratio exceeded by only a few of the most successful of the national colleges. How much its successes and failures have been due to the peculiarity of its situation can not with propriety be discussed at this point.

A third plan adopted by some of the states was to establish a university something like that of Cornell in New York, which aims to teach everything, or like the University of California, which offers four courses to graduates and eight to undergraduates. Illinois established an institution which had ten courses, and was called an industrial university, a name which was also adopted by Arkansas, while the simple term "university" was adopted by Ohio, West Virginia, and Wisconsin. These insti-

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tutions are not, as a rule, criticised as sharply as those of the first class, but like them they do not do their best work in agriculture, if we may judge from the courses selected by students.

Just now an item is floating through the papers to the effect that Ohio has not graduated as yet an agricultural student.

Cornell University, where nothing is spared to give the best instruction in agriculture, has fifteen agricultural students, or less than one for 300,000 inhabitants, and of the graduates for eleven years four per cent. are connected with agriculture, while eleven per cent. are connected with engineering.

Illinois has 21 agricultural students,—one for 143,000 inhabitants; and among the 303 university graduates of ten years, 13 per cent. are connected with agriculture.

In the great University of California there are 11 agricultural students,—one for 79,000 inhabitants. According to a newspaper statement, 19 students have been graduated from this course, and less than half of them are farmers.

The colleges of a fourth class were established independently, and were called, for the most part, colleges of agriculture and the mechanic arts. Some of these institutions are nearly as broad as the universities. Most of them give at least half of their strength to agriculture, and the rest to mechanical or civil engineering courses. Purdue University in Indiana seems to belong to this class, though not in name, while the college of Alabama does in name, although it has four courses, one of which is literary.

In Georgia there is a central college, and then there are four other institutions, one for each of the "four corners" of the state. They take the name of college, but apparently do the work of a New England grammar school. The newly organized college of Kentucky, that of Mississippi, and a second college in Mississippi for colored students, also belong to the class of colleges of agriculture and the mechanic arts.

South Carolina, like Mississippi, has two institutions, and Virginia, besides supporting a college of agriculture and the mechanic arts, gives part of the funds for supporting Hampton Institute, which is doing a most successful work for black students and red students, but upon a plane lower than that upon which colleges work.

With the mention of Texas and Maine the list is closed. The

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college of the latter state has graduated, from 1872 to 1882, 180 students, of whom 11 per cent. are connected with agriculture, and 20 per cent. are engineers. If we suppose one half of the students to be agricultural, we have one for 16,000 inhabitants. So in the representation of the inhabitants by agricultural students, as well as in the per cent. of the graduates who are connected with agriculture, Maine stands third among the New England states, coming after both Massachusetts and New Hampshire. In fact, in proportion to numbers, New Hampshire has furnished agriculture with nearly three times as many graduates as has Maine.

In a fifth class may be placed those few states which had agricultural colleges at the time of the passage of the national act, and so reinforced them with the new funds; and also that larger number of states which formed what they called agricultural colleges. In some cases the fund was divided, as in Massachusetts, and part of it used for a school with one course, pretty technically agricultural. In other cases the title was agricultural college, but the field covered was almost as broad as that of a university. One such college,—that in Colorado,—has been organized so recently that not more than one class, if any, has been graduated.

Among the remaining states,—Michigan, Massachusetts, Kansas, Iowa, Pennsylvania, and Maryland,—we find the best and most successful institutions, viewed from the purely agricultural standpoint. Not that these colleges are made successful by a single idea pervading all their work, for they have not been thus limited. Priority of organization, large endowments, and material support, explain the success more fully.

One of the pioneer colleges existed in the state of Pennsylvania, and it was exclusively agricultural in its first years, though much changed at present. The trustees made labor their cornerstone, and required the students to do everything. Not only they performed the labor of the farm, they managed the kitchen as well. The Iowa college, in a later time, has utilized student labor within doors and without; but Iowa recognized co-education, while the young men of the Pennsylvania school were left to their own resources.

At the very beginning the school was filled with students, and

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many were turned away. The college was fortunate in possessing a remarkable president; it was unfortunate in having no fund, and in being obliged to contract a debt for the building itself. After five years the president died, the students began to enlist in the war, and the debt had mounted up to $80,000. The institution had been called a farmers' high school in the beginning, but after the national endowment it broadened its scope and changed its name. Under the protest of the faculty, the labor system was abandoned after a few years. The institution can hardly be called narrow in its present condition; for it has six courses of study, has Greek in one of them, has a sixth of its students engaged in the study of music, and half of the whole number in the preparatory course, while fully a fourth are females.

In 1881 there were about 60 students in the college course, a number which cannot give more than one agricultural student to 200,000 of the population. During twenty years of its history it graduated 105 students, 18 of whom became farmers and 15 lawyers.

Another one of the first agricultural colleges was in Maryland, and was established in 1857. It has apparently been fairly successful. Between 1875 and 1878 it graduated 13 students. It had, in 1881, 55 students, but these, only in part, were agricultural, as the college has a classical course. Hence the number of agricultural students cannot be more than one for each 30,000 of the population.

One of the most criticised, but on the whole one of the most successful, of the purely agricultural colleges, is that of Massachusetts. Its number of students is about 120, or one for 16,000 inhabitants. Its classes from 1871 to 1880 gave it 164 graduates, while 35 per cent. of these graduates are connected with agriculture, and only 6 per cent. with engineering. Its course has been somewhat meteoric, but its position at present seems better assured than it has been for several years.

The Iowa Agricultural College opened its doors in 1868, and had about two hundred students in the beginning. It received a yearly income of $36,000, while the state constructed a building which cost $170,000. It makes no distinctions of sex, and though agricultural in name, is not entirely so in its instruction.

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Before the first class graduated, instruction was furnished in civil engineering, mechanical engineering, mining engineering, and architecture. This college has only one course of study, but offers a number of electives, while each student is required to give one hour per day to some kind of industrial training. With male students this means agriculture, carpentry, iron work, printing, or telegraphy; with female students, sewing, telegraphy, printing, music, or scroll sawing. It possesses a professor of military science, who gives twenty-six lectures upon the subject, but military drill itself is optional.

Somewhat the same may be said of the Kansas State Agricultural College. Besides the usual instructors, the faculty list shows a teacher of instrumental music, a superintendent of sewing, another of telegraphy, and a third of printing. From the latter department comes a small monthly sheet, which is edited by the faculty.

Of all the colleges, apparently the most successful is that in Michigan. It seems to have overcome all opposition. It early came into favor with the people, and it has done good work from the beginning. Although the per cent. of the state's population which is found in the college is not much greater than in other states, the size of Michigan is sufficient to give large classes. At entering they contain eighty or ninety students, but at graduation not more than a third of that number. The college has been particularly fortunate during all its history. It graduated its first class in 1861, and just at the period when a college keenly feels the demand for more money the large national grant came to its aid. The newly organized colleges in the other states turned to Michigan for professors and instruction in agriculture, and thus added to the home reputation of the college, and made agriculture especially attractive to its students. And what is still more important, the state has pursued a most generous policy, giving large appropriations whenever they have been needed. The appropriations in 1881 exceeded $50,000, and the amount received during the twenty-five years since the foundation of the college is over half a million of dollars. One peculiar thing in connection with the institution is the fact that its trustees and the State Board of Agriculture are



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identical, and consequently one report is all that is ever issued for both state board and college corporation.

The Michigan college has about 200 students, or one for 8,000 of the population of the state. From 1861 to 1882 the college graduated 244 students. Of these 51 per cent. are connected with agriculture, while only 3 per cent. are engineers.

In Florida no college has been organized. Leaving out that state, we find forty-six institutions having the benefit of the national grant, and giving some form of scientific instruction. There are nearly as many more schools which are scientific in form, or have scientific departments, two or three giving some form of agricultural instruction. And there are nearly as many other institutions as these combined, which grant some form of a scientific degree; so annually, of about twelve hundred degrees of a scientific nature, about a third come from the nationally endowed colleges, which, according to the *Educational Report* of 1880, have forty-five hundred students in scientific courses. As only one third of these students are pursuing studies connected with the industries, and there are only thirty of these colleges that have an agricultural course, there are probably about one thousand students, excluding those in preparatory courses, who are engaged in the study of agriculture.

The increase in the number of general scientific students in the country has been very remarkable,—ten hundred per cent. in ten years; but this increase has been kept down by agriculture, and crowded up by other subjects. The departments of the colleges that are developing most rapidly to-day are those for instruction in the mechanic arts. Even in the purely agricultural colleges, like that in Michigan, which give only one course, there is a strong movement in favor of work-shops and work-shop instruction.

In regard to preparatory departments, they are found in more than half of these national colleges. Some of them are found in the West, and they are common in the South, where a poverty of good schools makes the preparatory department of an agricultural college much the larger part of the college. In the five colleges of Georgia, five sixths of the students are in the preparatory classes.

Many of the colleges attempt to secure popularity with the

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farmers by opening special courses in agriculture, by offering short courses in chemistry, and by giving special lectures during the winter months. Vermont has tried this latter plan with little success; Ohio more successfully, as the attendance has reached at one time one hundred and sixty. New Jersey offers a two years course in addition to the regular one, and Tennessee has a special course of the same length of time. Students in this course are divided into two sections, each section reciting during one half of the week, and working during the other half.

Most of the agricultural colleges make a special point of giving help to students in the form of pay for labor. Some make the labor compulsory,—a plan that is becoming unpopular, and will probably be abandoned. The prices paid are sometimes graded,—frequently not more than eight or nine cents per hour. The twelve and one half cents per hour paid in the New Hampshire college is probably as much as is paid in any college.

In all these colleges the expenses are less than in other scientific schools. In some the tuition is free to all; in most, scholarships make it practically so, and the strong tendency is to make tuition in all of these institutions entirely free.

Of all forms of instruction found in the colleges of the United States, those connected with the colleges of agriculture and the mechanic arts are the most expensive. At the point where the instruction in the classical college has been provided for, the expense in a technical institution has but begun. And in fact, the most expensive features in instruction connected with the old colleges of the country are those which are taken from these scientific institutions. There are courses, like those in civil engineering, in which instruction is comparatively inexpensive; but the scope of the national colleges requires model farms, expensive buildings, experiments always costly, and workshops with machinery and tools,—all of which are non-productive, and a constant source of expense. Hence these colleges appear as chronic beggars in the state legislatures; and the successful institutions are most of them successful beggars. The first demand upon the states was for buildings, but now, with buildings and endowments, most of these state colleges find that they must ask for annual appropriations, or fail to do the work demanded from them. Sooner or later nearly every state voted appropri-

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ations. In Alabama the buildings for the college were given by the Methodist church, and nothing was granted until a few months ago, when the trustees went to the legislature with the statement that thirty-three similar institutions had received on an average $130,000 in appropriations. The reply to this was a vote giving $150,000.

In income, Cornell heads the list with its $230,000. Next comes the University of California, with a yearly income of $100,000, while it has received more than any other college in appropriations. It has received from the state $35,000 for its library, nearly half a million of dollars for its buildings, and over a million for general expenses. The Iowa college, with an income of $44,000, has received nearly ten times that amount in buildings; while the state of Minnesota, in addition to gifts amounting to a third of a million, has recently passed a bill making a yearly appropriation of $30,000 for the state university. The income of $4,800 received by the state college of New Hampshire is the smallest income received by any one of the colleges doing independent work.

Upon the income of $30,000, Pennsylvania has been trying to support its college and three experimental farms, but through a series of difficulties, misunderstandings, and financial troubles which culminated in a legislative investigation in 1883. Whatever conclusions may be reached from the three hundred pages of contradictory testimony, one fact is certain,—that college must reduce its scope, or increase its funds.

In these days of a large national income and internal improvements, it is quite possible that congress will make some further recognition of the national colleges. Help may be given them without increasing their funds or adding very much to the expense of the work now being done under the direction of congress. One of the most reasonable and simple plans proposed is to establish in connection with each college an experimental station, under a management recognizing the commissioner of agriculture, the local college, and the agricultural board of the state. These all may be arranged so as to make a division of experiment work, giving each college practical instruction, each state a series of valuable experiments adapted to its situation, and the government and the nation fuller and more valuable

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information than can now be gathered into an agricultural report.

Some of the colleges commenced operations on the broad basis, that being endowed by the nation they had no right to make any distinctions of sect, sex, or color. So coeducation soon became an established principle among the colleges of the West, and from the West has come to the national colleges of the East, until at the present time women are admitted to a majority of all these institutions. In many of the colleges they form a large fraction of the students. One of the catalogues of the Kansas college shows that a third of the two hundred and fifty students are women. This institution has added special instruction in telegraphy and printing, and in cooking and sewing. Nebraska and Pennsylvania furnish instruction in music; but in most colleges women taking the courses find few or no modifications for their benefit. One University, which gives a combination of all sorts of instruction, kindly explains that "bachelor is a degree word having no reference to sex, and may be given to girls," but sternly adds that "A. D. B. (bachelor of domestic arts) points to home life as the destined sphere of women," and can be granted to no males.

Although agriculture was only one of the subjects contemplated in the national scheme, it was intended to give it a prominent place in these colleges. It has been specially under consideration in state appropriations, and is the one thing in which there has been a general desire to do successful work. Each college has, in a great measure, worked independently of every other college, and yet the agricultural courses of nearly all the successful institutions are nearly the same. There have been attempts to provide short courses of not more than two years, and to make the education outside of technical agriculture consist of only the merest rudiments; but nothing of the kind has thus far met with success sufficient to recommend it to other colleges. It is successful at Hampton, Virginia, where the problem is to give negroes and Indians civilization, rudimentary education, and a knowledge of the first principles of agriculture. But any such system bids fair to be a failure among young men, who understand all of the ordinary details of farming before they enter any institution. Those who will leave a farm and go

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to any kind of a college are men of sufficient character to despise any course that does not put them on something near an equality with graduates of other scientific institutions.

While general culture has been given a prominent place in other technical schools, it has been especially needed in the agricultural colleges; for the latter, much more than the former, have been obliged to take students from the common schools, and to give them all the culture and general education ever obtained by them in the school-room.

Into the scheme of agricultural education at least four things must enter. First, those studies giving that knowledge which especially and alone distinguishes the educated man from the uneducated,—that is, a knowledge of the national language, literature, and history. These studies are prominent in all the national colleges, which in most cases have also the modern languages, and in a few cases the dead languages.

The second requisite for agricultural education is a thorough scientific training, with mathematics sufficient for surveying, and an understanding of mechanics.

In the third place, there must be a special prominence given to chemistry, and those branches of natural history which are connected with agriculture.

Last comes the study of technical agriculture. It is true that agriculture is one of the most complicated of subjects, and that all of the sciences enter into it. It is also true that as a science it has not developed as rapidly as other sciences, and that a great deal that has been written about it has been written by men ignorant of the subject, who have darkened "counsel by words without knowledge." Here is one of the difficulties in the way of the instructor in agriculture. While in engineering there have been many excellent class-books, in agriculture it has been necessary for the instructor to depend upon lectures and illustrations, and at the same time cover a field so broad that a high grade of work has been nearly impossible. That difficulty has been partially overcome, and in the future much more will be done than has been done in the past. On several agricultural subjects good text-books have already been written, and more are to follow.

Of these technical subjects there are many that deal with

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crops and fields, and are really to be reached through experiment work; but there are other subjects that may be studied through books, or through books and experiments together.

Dairying is one of these subjects. Upon it there is an excellent text-book, and the supplementary work is not difficult.

Farm drainage can be studied through at least three text-books. There are also recent works upon forestry and irrigation.

Stock-breeding can be studied through the work of a professor in one of the agricultural colleges.

Such subjects as animal nutrition, plant growth, and soil fertilization are more complicated, but are not beyond the reach of text-books, lectures, and practical illustration.

Veterinary science is another technical subject which is within the scope of the agricultural colleges, and owes to them part of its development. In the past the quadrupeds have been delivered over to the tender mercies of local horse doctors, who have considered that animals have no right to more than one or two diseases, and have consequently employed but one or two specifics. Animals inventing new diseases have been punished by being compelled to take the regulation dose, and have seldom transgressed more than once. Mr. Beecher tells a story of a doctor that once took charge of a sick horse for him. This man of science punched the animal in various parts of its body, and then, with a look of profound wisdom, pulled out a handful of hair, which he rolled into a ball, and forced down the throat of the patient. As the science stands to-day, it has, in a single city of the United States, two colleges for veterinary education, and two journals apparently of a high grade. In other parts of the country there are other colleges. There are many works being written upon the subject, and the agricultural colleges are making it a marked feature in their instruction, while Cornell gives to it a special course. It is not claimed that an agricultural college can make every graduate a veterinary surgeon: it can give the state one man competent to deal with the questions arising in connection with wide-spread animal diseases, and it will give every agricultural graduate sufficient knowledge to allow him to relegate the horse doctor to the locality of surgeon barbers.

The present tendency is to give experiments an important

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place in the work of agricultural colleges. When they are such simple experiments as can be performed by any intelligent farmer, the college merely prevents a duplication of work, and assumes the load of all the blunders and losses for a state. From this the experiment station rises in importance through a grade of work too expensive for private enterprise, until it reaches the heights attained by such experimenters as Laws and Gilbert. On this ground it has been claimed that an agricultural college, even without a student, may give back to agriculture more than it has cost.

The result of a single experiment may save a state thousands of dollars, and only a small fraction of the great number of experiments tried need be successful to pay back the cost of all the experiment stations in the country. Such work in connection with an agricultural college answers a double purpose. It is valuable in results for the farmer; it is valuable in instruction for the student. While mere compulsory manual labor for students is expensive, unpopular, and unsuccessful, work in connection with experiments is educating, and helps to build up a class of graduates who will do for agriculture what the great inventors have done for manufactures.

Experiment work begun by colleges has been recognized by legislatures, until experiment stations, by means of bulletins and annual reports, have become one of the great agricultural educating influences of the country. With the better facilities now being obtained the value of the work is likely to increase, while the number of aimless experiments will decrease. To reach the highest results, it is necessary to have some system by which the colleges shall work in connection with the department of agriculture.

When all the national colleges, and particularly those that make a specialty of agriculture, have passed through the period of unsparing criticism and extravagant expectations, we may expect the best work from them. They need not be expected to revolutionize agriculture: they cannot give a direct education to every man who tills the soil. If we take the most successful college in the country,—the one that is fitly considered as a model for the other colleges,—we find the students enjoying its benefits are only about one eight thousandth of the popu-

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lation of the state, or perhaps one student for every thousand men in the state who are engaged in agricultural pursuits.

The proportion is still further reduced when it is limited to those of the graduates who are connected with agriculture. Of the graduates of the model and exclusively agricultural college of Michigan, about fifty per cent. are connected with agriculture, although part of these are teachers of agriculture, presumably with good salaries. The Massachusetts college sends about thirty-five per cent. of its graduates into agriculture; that of New Hampshire, although not entirely agricultural, about thirty-three per cent.; the college of Maine hardly more than eleven per cent.,—while most of the colleges in other states fall still lower.

Such facts as these are often made the grounds of very sharp criticism, and sometimes the grounds for chronic grumbling.

There are just three potent facts that are forgotten in all these cases:

First. The history of the movement before the national law, and the law itself, show that these colleges were never intended to be exclusively in the interests of agriculture. They were intended for the practical education of the industrial classes, and that is the work they do, even if two thirds of the graduates do not become farmers.

Second. The reasons that keep young men from becoming farmers are so far back that no college can reach them. They act upon the young men who go to agricultural colleges and those who do not, and are evident to even the most careless observer in any farming community. Those students who enter college intending to remain farmers, graduate well equipped for the work; those who enter an agricultural college determined not to be farmers will graduate with the same mind. But one of the great things that keeps agricultural graduates from farming is a want of capital. A considerable part of these graduates are men who have intellect and energy, but no money. Like other men and most farmers, they turn where they can make the most money, and that is frequently not in agriculture. Many a graduate who prefers farming in the beginning never becomes a farmer.

Third. The number of students in the colleges and the per

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cent. of the graduates upon the farms of the country afford no adequate measure of the influence of the colleges upon agriculture. There must be an influence from the graduates actually in the work,—the sixty of Massachusetts, the thirty of New Hampshire, and the twenty of Maine. Three agricultural colleges in little New England have in a few years put over a hundred educated men into the work of agriculture, and the one college of Michigan has furnished more than the three together. But that the influence is unmeasured by numbers seems shown by the way in which every improvement originating from the college is shared by the public. If one of them were to discover some process revolutionizing the science, it would be in the hands of farmers almost as soon as in the hands of graduates. The very existence of such colleges has added to the dignity of agriculture and the social position of the farmer. For him the sciences are being ransacked, labor and learning are laying their stores at his feet. For his benefit, about the colleges are collected groups of specialists, and for his benefit are going from their doors young men with a training that will fit them to become the specialists of the future.

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# A BARN-FLOOR LECTURE.

BY DR. J. R. NICHOLS, OF MASSACHUSETTS.

[Though the accompanying lecture is not new, it is of value, and is published with permission of the author, by the request of farmers who are unable to obtain copies.—SECRETARY.]

GENTLEMEN:—I have invited you here to-day in fulfilment of a desire long entertained, of bringing around me for a couple of hours, on my farm premises, a body of practical men—workers in the field—that I might illustrate and explain to them methods of procuring, manufacturing, and combining those important elements of plant food which modern science has brought to view within the past quarter of a century. We meet under peculiar circumstances and in a peculiar place, but in one most appropriate. We are under the same roof that shelters the products of these fields and the animals we so highly prize, and here around us are the implements of husbandry; and it is here that for a period of sixteen years I have studied and experimented upon improved methods of farm management, and the fertilization of crops. It is here that as long ago as 1863 were commenced systematic experiments with what are known as chemical fertilizers, and probably there is no farm in the country which has been so long an experimental one as this to which you have been called to-day. During the time it has been in my possession, Lakeside farm has more than trebled its productiveness; and when I tell you that not a load of animal excrement has been purchased, and that the only animals maintained the first five years were a couple of cows and two horses, and that during the past five years but six animals, all told, have

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been kept to supply excrement, you will understand that I must have maintained fertility through some other sources than the manure heap. During the intervening period between 1868 and 1872, a herd of seventeen animals, mostly cows, was kept at the farm, and the use of chemical fertilizers was suspended except upon experimental fields. The productiveness of the farm diminished during that period, and my anticipations were verified by the results.

The farm is now mainly devoted to raising hay, as the soil is well adapted for the growth of grass. Our crop the present season is probably not far from fifty tons. The present is the first season that a corn crop has not been raised. There is a field upon the hill yonder from which have been taken two fine corn crops and one of rye in the past three years, using only our farm-made chemical fertilizers. The land was rough pasture, covered with stones and briers, before it was put under the plough. The field opposite this barn is an experimental field, or rather was for a period of ten years. From that field have been gathered three crops of corn, two of rye, one of wheat, and four of hay, in ten consecutive years, and the dressings have been solely chemical food, such as the crops required. At the expiration of ten years it received a thorough dressing of barnyard manure, eight cords to the acre. A diminution of crops followed, and it is not now in satisfactory tilth. A good illustration of the value of chemical fertilizers, properly adjusted and compounded for grass, may be seen in the richness and luxuriance of the lawns connected with the stone mansion in view on Winnekeni hill. These lawns are four acres in extent, and no part has ever received any barnyard or stable dung. The soil was common pasture, and never probably received any manure other than the droppings of the animals feeding upon its grasses. At the close of the meeting I trust you will find time to examine the grounds.

But, gentlemen, this is not properly a field meeting, it is a *farmer's barn* meeting, or, for the time being, we will call it our agricultural college, and I promise to graduate you all in about an hour, without diplomas. You are to learn how to prepare, combine, and use the new fertilizers about which so much talk is made in these modern times. I have always taken the ground

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that farmers can and should prepare their own fertilizers on their own premises. This has been advocated in addresses before our State Board of Agriculture, and in all my writings upon husbandry, and now it is designed to show you here how it is or can be done. Probably never before in the history of agriculture in our country has a meeting like this of farmers been held in such a place for such an object. It is new, it is an experiment, but there can be no doubt of its entire success. I have great confidence in the eye—I believe in seeing: sight is the readiest avenue to the mind. At the close of the lecture, Mr. Davis, the efficient superintendent of this farm, will call you into the barnyard contiguous, and then, with apparatus and implements such as are used on the farm, will proceed to prepare, not simply an ounce or a pound, *but five hundred pounds* of superphosphate of lime, the most important of all forms of plant food. He will also show you other combinations of fertilizers, a knowledge of which it is important to possess. You have seen the room or laboratory below, simple, plain, and without machinery, in which the fertilizers for the farm are prepared. In that room, Mr. Davis, during the past winter, made about twelve tons of superphosphate of high grade, analyzing sixteen per cent. of soluble phosphoric acid, and also several tons of other compounds used in the various crops on the farm. He will use three hundred and eighty pounds of bone charcoal, and a carboy of oil of vitriol of one hundred and sixty-five pounds, in making the superphosphate; and you must observe all the proceedings, observe how he handles the carboy so as to avoid spilling or slopping, how he mixes the bone with the acid and water, how he manipulates the mass with his wooden hoe. The box in which he will make the mixture is of wood, four feet square and one foot deep, and it is lined with thick sheet lead, the lead in one piece, soldered at the corners strongly with lead solder. A tin solder will not do, as the acid will act upon it. This box is the result of much experiment, and is the best and cheapest vessel that can be devised. Its capacity is just right for making one fourth of a ton of superphosphate at a time, and it requires a whole carboy of vitriol, so that no fractional parts of acid are left to cause trouble. He will use in the manufacture,—

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| | |
|---|---|
| 1 carboy oil of vitriol, . . . . . | 165 pounds. |
| Bone charcoal, . . . . . | 380 pounds. |
| Water, . . . . . | 10 gallons. |

The water is first placed in the trough, and the acid is added to it; then the bone is gradually added causing a great boiling, with evolution of heat and steam, as you will see. You observed in the laboratory that there were roof windows that could be opened for letting out the steam: these are necessary. It takes about an hour for the reaction to become complete, and then it will soon dry and be free from moisture. It needs no grinding; it is ready for the field as soon as cool. Specimens of each lot as made here are taken to the analytical laboratory, and analyzed to ascertain how perfect has been the reaction. You have visited the laboratory, up stairs, at the end of the building. This is necessary for the chemist, as it is there all his results are worked out, but it is not needed by you. You will need a cheap room with good ventilation for the manufacture, and the simple implements you see here are all that are necessary.

In order that you may understand the nature of the materials and compounds we prepare, I will now proceed to state the chemical constitution of bones, and what changes bone structures undergo when subjected to chemical treatment. The bony framework of men and animals is essentially alike, and the molecules of which they are composed come from the foods consumed. The bones which hold up the muscles and integuments of our animals come from hay, grain, green forage, &c. It is necessary for cows to procure a much larger amount of bone material than they need for the repair of osseous waste in their bodies, for the composition of milk calls for a large amount of the phosphates. When you learn that in about every thirty gallons of milk there is one pound of tribasic phosphate of lime, or bone material, you will have some idea of the importance of this substance in the food of cows. The bones of the infant, fed on milk, come from this principle; and hence we learn the medium through which human or animal structures are built up. Permit me to remark in passing, that it must be obvious to you that an animal in milk, like a cow, cannot yield excrement of high value. Most of the rich material obtained from the pasture, or from any form of food, goes to the milk,

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and hence little is left of value to return to the soil. We often hear farmers say they keep cows and sell milk so as to maintain the fertility of the farm. This is absurd, on the principle that you cannot eat your pudding and have it too.

A cow in milk requires about eighty pounds of bone material a year, and consequently a herd of twenty-five cows will carry off from our pastures and the barn a ton of bone materials each year. It is apparent that this process of exhaustion cannot continue for a very long period without rendering our fields sterile. We must return to them the bone material they have lost: we must, in other words, feed our hungry plants upon the soluble phosphate of lime, and thus give to them renewed vigor; and they in turn will yield the same back to our animals, and from them our own bodies will be nourished. Plants cannot assimilate bone in its ordinary condition; it must be rendered soluble in water before it can enter plant structure. How this is accomplished it is important to understand. Phosphoric acid, the element in bone which plants require, and which therefore becomes what we call a fertilizer, is not the only kind needed to render our fields productive. It is one of the three great essentials of plant food, for there are but three that we need trouble ourselves particularly about. The others are nitrogen and potash. It is proper to remark here that the great bulk of all vegetable structures comes from the air, and is therefore furnished abundantly and gratuitously. What concerns us directly is the matter of furnishing proper supplies of phosphoric acid, nitrogen, and potash to our fields and crops, and it is our business to learn how to obtain, prepare, and apply these substances.

Now, first let us consider phosphoric acid, what it is, and how we are to fit it for plant nutrition. I shall use in the experiments this afternoon what is known as bone charcoal, for the purpose of developing or setting free phosphoric acid, and here it is in the vessel before you. It is, as you see, a black, granular substance, resembling coarse black sand. This substance is simply burned bones, bones charred or changed into animal charcoal by heat. The animal portion, or the gluten, is carbonized, and the bone structure destroyed. It is a substance largely employed by sugar refiners to decolorize syrups, and after it

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has served that purpose it is sold to makers of fertilizers to be changed into superphosphate. What is the meaning of this word, so often brought to the attention of farmers? Super means above, over, or higher. When prefixed to the word phosphate, or phosphate of lime, it means that lime is overcharged with phosphoric acid. In this vessel I have a fine white powder, in mass, as you see: it is pure bone powder. Now, this is composed of lime and phosphoric acid: it is a phosphate, but not a *super*phosphate, of lime, because it holds three parts of lime and only one of acid. If it were like the powder in this vessel I have in my hand, it would hold only one part, or equivalent of lime, with the same of acid, and then it would be *super*phosphate.

Lime is a substance, the nature of which you very well understand, but of phosphoric acid you know less. I can show you here upon the table this most interesting acid in two forms. In the vial I have what is known as glacial phosphoric acid. It resembles ice, and hence its name—a very beautiful substance, hard, transparent, and intensely sour. In this vial we have it in the form of a clear, colorless liquor, about as dense as syrup. This is prepared from the jet black superphosphate you see upon the table. Phosphoric acid is an indispensable constituent of plants: not a plant exists which has it not. How it happened to become necessary in plants—this wonderful acid—we do not know. In bones it exists locked up most firmly. Every molecule, or little particle, is in the embrace of three molecules of lime, and they hold it so tenaciously that we cannot make it available for plants unless we proceed violently to tear the molecules asunder and drive the lime into new combinations. This we accomplish by the aid of strong sulphuric acid, oil of vitriol.

Now let us understand this matter, so that when Mr. Davis mixes that fiery liquid, that carboy of vitriol, with those two barrels of bone charcoal, we shall know just what happens. Vitriol, you say, will burn our clothing, our flesh, and so it will, and yet we are going to pour it on to that bone, and in one hour not an ounce of the vitriol will exist as such. The black liquid will seethe, and boil, and hot steam will rise, and in one hour you can put your hand into the mass, and handle it as

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you can sugar. What becomes of the vitriol? I will tell you. The bone is composed, as we have said, of three equivalents of lime and one of phosphoric acid. Now the vitriol has a strong liking for lime, as it seizes hold of it whenever it can reach it, and becomes locked up in its embrace, and sulphate of lime is formed. This is the gypsum, or plaster, with which you are well acquainted. The whole of that ten gallons of acid is to become locked up with the lime in those barrels of bone, and it will disappear in its new combination completely; and now you ask, What becomes of the phosphoric acid? Well, that is a pertinent question. As soon as the vitriol seizes the lime, the phosphoric acid is set free, as it were; but a kind of vacuum exists, the condition of that acid is an unnatural one, and hence it associates itself with an amount of water sufficient to replace the lost lime. The vitriol will seize but two of the three atoms of lime, and so the phosphoric acid is left in the form of what chemists designate a mono-calcic phosphate—that is, it holds one equivalent of lime and two of water—and now it has become soluble. We have prepared a vat full of superphosphate, and that is composed of phosphoric acid soluble in water, lime, and gypsum: by far the largest portion of the bulk is gypsum.

It has been my endeavor to avoid the use of technical terms, the true language of chemistry, in order to render every statement intelligible to you. I will now venture to put upon the blackboard some diagrams, or tables, which I hope will make very plain the reactions or changes which bones undergo in manufacturing superphosphate. There are three forms of phosphate of lime—that is, lime is held by phosphoric acid in three proportions. In naming them I must use the chemical terms. Your attention is called to the illustration upon the black-board:

| Tri-calcic phosphate. | Bi-calcic phosphate. | Mono-calcic phosphate. |
|---|---|---|
| Phosphoric acid. | Phosphoric acid. | Phosphoric acid. |
| Lime. | Lime. | Lime. |
| Lime. | Lime. | Water. |
| Lime. | Water. | Water. |



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In this diagram we have a clear illustration of what I have endeavored to state to you. Plain bone without the animal part is tri-calcic phosphate, phosphoric acid, lime, lime, lime; bi-calcic phosphate is phosphoric acid, lime, lime, water; mono-basic phosphate is phosphoric acid, lime, water, water. Mr. Davis will act upon the three lime phosphate, and change it over into the one lime phosphate with his vitriol. He begins with an insoluble substance, that is, insoluble in water, and leaves off with one that is soluble. All the phosphoric acid held by three equivalents of lime is now held only by one. If he took fine ground raw bone he would reach the same results, so far as chemical action is concerned, but he would have a pasty mass, very difficult to dry. If he took the Charleston powdered phosphatic rocks, he would have a dry and manageable powder after the reaction is over. Therefore, you cannot well act upon raw bones, either fine or in small bits, satisfactorily, but you can upon bone char, or the rocks of the Charleston marl beds.

Now, you ask if this superphosphate will remain soluble as it has for a long time? I answer, Probably not all of it. The mono-basic phosphate has a tendency to go back, or revert, as the change is sometimes termed; and this means that it will, to some extent—that is, the phosphoric acid—take up another equivalent of lime in the compound, and thus become bi-basic phosphate. I regard this as a not unfavorable change, for the reason that it is more slowly soluble in the soil, it is not so quickly available, and therefore is more enduring in its action upon crops. It is not certain but that we shall find it better to convert all of our phosphates into the bi-basic form, rather than into the mono-basic, as that form of acid may be too strong to be assimilated by plants. We do not yet know precisely in what condition the acid is taken up: we certainly know it must be soluble in water, however.

But you may say, perhaps, that bones have proved excellent fertilizers without dissolving them in acid. That is true, but you must remember that in such condition the carbonic acid of the soil and air does the work of the vitriol in the laboratory. The lime of the bones is seized by that acid, and it becomes carbonate of lime; this sets free the phosphoric acid, and it is made available to plants. It is, however, a slow process unless the

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bones are finely ground, and much better to render them more speedily available, as money interest is to be considered. In what I have said about the importance of having plant nutriment soluble, you will infer that water is needed to serve as the important solvent. If any form of fertilizer is used in a dry season, it is not of service for want of water to hold it in solution; and that fact we must never lose sight of. The peach orchard by the hill yonder received for six consecutive years dressings of bone and other substances, but during the past seven years nothing whatever has been given to it, and yet the hay crop continues to be very large. This year the timothy was very heavy, and I have no doubt the yield will continue good for some years. The explanation is, that we have had very many dry seasons since the dressings were applied, and, further, some of them were in condition to be slowly available. Two very nonsensical notions have somehow got into the heads of farmers respecting artificial fertilizers. One is, that such manures are quick gone; the other, that they burn up, or render soils in the long run sterile. Look abroad, gentlemen, on these fields, for sixteen years under these fertilizers, and judge if they are sterile, or likely to become so.

Now I must turn to a brief consideration of the other important substances employed as artificial fertilizers; and, first, let us consider the sources of nitrogen. In the use of the name of the element, it must not be understood to mean that nitrogen in its naked condition is available. I once had a farmer call at my laboratory in Boston, and ask if I could furnish him nitrogen, and if so, the price. He was told he could very easily obtain all he wanted without much cost, by simply burning phosphorus in confined air. This substance will attract and appropriate nearly all the oxygen of common air and leave the nitrogen free for use. But "he wanted it in considerable quantities for fertilizing purposes." Ah, you are now understood; that is quite another matter. You cannot use nitrogen, as it exists in air, and a pity it is that we cannot, or seemingly so.

Nitrogen is only available as it exists in some one of its combinations, as nitric acid, salts, or ammonia. Nitrogen, in itself, is a dead, negative element, and yet in its combinations it is the source of some of the most startling exhibitions of explosive

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force which come under our notice, and also in plants it is the element which gives to the cereal grains the power of producing and sustaining in men and animals all the muscular and nerve force they are capable of exhibiting. There are, upon the table, vessels holding nitrate of soda, sulphate of ammonia, nitrate of potassa, and also animal dust and guano. You have had opportunity to examine them, and now know how they look, and what is their physical character. I have brought them here that you may see them, as they represent about all the sources from which at present we are able to obtain nitrogen for agricultural purposes. They are commercial substances, and are to be bought in the market the same as flour or sugar. In their use, or in their purchase, we are to be governed solely by two considerations,—price, and nutritive value as plant food.

By analysis, it is found that this nitrate of soda holds 95 per cent. of the pure salt, and, from this calculation, it is known to contain 16 pounds of nitrogen in each 100 pounds of the crystals. This crude sulphate of ammonia has 25 per cent. ammonia, and it contains 16 pounds of nitrogen in each 100 pounds. I find this dried blood, made at the Brighton works, to contain 10 per cent. ammonia, 8½ pounds of nitrogen. This guano is what is called "Rectified Guano," treated in New York. The statement put upon the packages is wonderfully truthful. It contains,—

Ammonia, 10 per cent.,
Phosphoric acid, 10 per cent.,
Reduced phosphoric acid, 3 per cent.,
Potash, 2 per cent.

Thus in 100 pounds is contained,—

8½ pounds of nitrogen,
10 pounds of soluble phosphoric acid,
3 pounds of reduced phosphoric acid,
40 pounds of potash.

We thus have before us the important substances which hold nitrogen, and we know also how much they hold, and, further, the condition under which it is present.

Now, gentlemen, please remember what has been briefly said upon this topic, and keep in view the figures upon the black-

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board, as I shall come back to this matter again. The one other substance which remains to be noticed as belonging to the illustrious trio, or great essentials of plant food, is potash. Potash—we know very well what that is, and we are all willing to concede that it is an important substance, for we have tried it, as it exists in wood ashes upon our lands. If we were obliged to look to ashes alone for our supplies, our prospects would indeed be dark; but we are not, thanks to research and science. In the past ten years a new source of potash supply has been opened in Germany, at the Stassfurth salt mines, and the amount obtainable is apparently inexhaustible. Doubtless we shall soon discover rich potash deposits in our own country, as we have good reason to believe that our resources in every direction are fully equal to our wants. The potash from Germany comes to us in the forms of kainit, muriate, and sulphate of potash. Upon the table we have large specimens of each of the salts for your inspection. You notice they differ in color, and also in their crystalline structure, and they also differ in their chemical nature.

This muriate of potash is found to be 80 per cent. pure, which affords us the following results, and I will give the analyses of the other salts in order:

100 pounds muriate 80 per cent. gives 50 pounds potash.
100 pounds sulphate 50 per cent. gives 29 pounds potash.
100 pounds kainit gives 12 pounds potash.

In stating the results of analyses, round numbers are given without troubling you with determinations chemically precise. The kainit is largely chloride of sodium (common salt), a preponderance which renders it not worth your attention as a source of potash. The sulphate and muriate are largely imported, and can be purchased of the importers and dealers under a guaranty as to quality, which guaranty can be relied upon usually.

I have thus, in the briefest manner possible, brought to your notice the three great essentials of plant food. It now remains to consider the special adaptedness of each to crops, and the methods of combination. As has been stated, phosphoric acid is a constituent of all plants, a kind of general food, and, there-

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fore, it must enter into all forms of combinations which we may devise for our crops. We find, however, that the phosphates have a special or marked influence upon some crops, an influence which is suggestive and important. It is certain that upon roots of the various kinds it has a special influence, also upon the cereals, corn, wheat, barley, &c. Nitrogen, or the nitrogenous compounds, are indispensable in any mixture designed for the grain crops. The noble grains, like wheat and corn, cannot flourish without a full supply of nitrogen. It is necessary, as these grains are designed to supply nourishment to both muscles and nerves, and, without nitrogen, the functions cannot go on normally. Potash is the *pabulum* of the potato and the root crops generally. Clover needs it, and also many of the soft table fruits. It was abundant formerly in our soils, but by constant cropping they have become impoverished of potash, and it is a much needed plant food.

Now, as regards combinations of substances, my friend Stockbridge, of the Massachusetts Agricultural College, has suggested some combinations which doubtless many of you have experimented with, and I trust you have found them useful. I have experimented much in this direction, and the results were given to the farmers of Massachusetts, through the meetings of the Massachusetts State Board of Agriculture, as early as 1871. Prof. Stockbridge generously gave credit for these researches at the meeting of the board, at Haverhill, in 1865. I had used combinations essentially like those now coupled with his name for several years prior to 1871, but I hesitated to publish formulas, for the reason that I hoped farmers would be led to study principles, and thus be guided by induction to construct their own formulas.

If we only knew what differing soils absolutely require to render them fertile, it would be easy to arrange mixtures or apply the *one* substance, which often is all that is required to put fields into good tilth. Analysis, unfortunately, does not supply the safe guidance which is desirable. We are not able from laboratory work to learn precisely what any given soil needs, and while it is possible to get at general conclusions from that source, and such as are important and useful, we do not learn how much of any one substance is needed to produce

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fixed crop results. We do as well to interrogate the soil itself as to make laboratory researches, and by this I mean that it is possible to learn approximately the true wants of our fields by carefully observing the effects of fertilizers when understandingly employed. This kind of experimenting, however, is not perhaps adapted to the culture or capacity of some farmers, for a considerable number of husbandmen are like Dobbins's horse, capable of drawing anything but an inference.

The formulas that have been suggested and extensively employed in this country are based upon the plan of applying sufficient quantities of the three forms of plant food, in proportions as suffice to meet the wants of a certain number of bushels of the cereals, tubers, and roots, or pounds of hay, above what the natural condition of the soil is capable of producing. While this plan is not in all respects objectionable, it is obvious that it does not afford safe guidance in its results, or that it may not be in the end wasteful. We can never know what a soil is capable of producing in an unfertilized condition, and therefore we can only guess at results. As we know, by analysis, what amount of plant food each crop requires, it is easy to construct formulas on that plan, and we may assume whatever we choose as regards the natural capacity of our soils.

In the treatment of my own fields I have pursued a plan which does not call for fixed formulas, or, rather, which does not admit of any uniformity in formula. Attention is given to the nature and wants of the crops which different fields produce from year to year, and the food supplied in all cases has reference to the crops raised and those projected. It is known what corn, wheat, rye, potatoes, hay, &c.. need, and supplies are furnished adapted to their respective wants. If a corn crop has been raised for two or three consecutive years upon a field, it is certain that an excess of the nitrogenous and phosphoric forms of food must be supplied if the succession of crops is to be continued; if not, and potatoes follow, then a dressing of potash alone is all that is needed. The fields themselves indicate their wants by the returns they make, and in this we are taught the wisdom of crop rotation. It is not alone what we apply to our fields that comes back to us in produce. It must be remembered that our fields hold large amounts of unassimilable food, and that it is

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the office of our fertilizers in part to change this inorganic natural food so as to be available or digestible. To render the natural rock food of plants assimilable, it must be so altered as to be soluble in water; and this is accomplished by the agencies of air, carbonic acid, water, &c. To these natural agencies promotive of soil decomposition, we must add that of our chemical fertilizers, which perform a secondary work of no mean importance.

But I must hasten to conclude. What we call a stock, or normal combination of fertilizing agents. has been used upon this farm under proper conditions. It is constituted as follows:

| | |
|---|---|
| Superphosphate of lime, | 40 pounds. |
| Sulphate of ammonia, | 25 pounds. |
| Muriate of potash, | 25 pounds. |
| Sulphate of lime, | 7 pounds. |
| Sulphate of magnesia, | 3 pounds. |
| | 100 |

Five hundred pounds of this is applied to an acre as a preliminary proceeding, or as a first dressing to a field of unknown fertility, or crop capability, and from the results, taking into consideration not only the crop but the meteorological conditions which prevailed, we deduce conclusions as to subsequent treatment. This combination is serviceable for all crops, and even if it is not followed by proper modifications from year to year, it gives valuable and profitable results. A very excellent liquid fertilizer is produced by dissolving in one hundred gallons of water,—

8 pounds of Peruvian guano rect.,
16 pounds of superphosphate,
8 pounds of muriate of potash,
1 pound nitrate of soda.

A less or greater amount may be made as may suit the convenience, the proportions being maintained. This liquid is excellent for use upon flower-beds and plants, and the growth of strawberries and raspberries is greatly promoted by its use. It is very convenient upon the farm as well as the garden, and

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might be used on a large scale in producing several crops of grass in a season, and for cereals and vegetables.

The substances before you are some of them of crystalline structure, and need to be crushed or pulverized before entering into field mixtures. We accomplish this by the free use of the hoe and shovel as they are spread upon the firm floor of the compounding room. They readily yield to such methods, and no mill is needed to grind any one of the products. After the substances are weighed, they are pulverized and mixed, and then, to secure thorough admixture and fineness, are passed through an upright sifter, made in the form of those used by masons in sifting sand for mortar. All of our tools, with the exception of the lead-lined tank, for making superphosphate, are made in the carpenter shop connected with the farm.

Those of you who have plenty of genuine wood ashes will find it to your advantage to use it in connection with fine ground raw bone in manner as follows:

Take 1 barrel of raw bone flour,
3 barrels of wood ashes, dry,
50 pounds of gypsum,
10 gallons of water.

Make a heap of the whole upon a floor, and add the water, stirring constantly with a hoe. This is perfect plant food, containing *all*, in desired proportions, which plants require. This we recommended to farmers fifteen years ago, and no greater service can be done than to again call your attention to it. The steamed or burnt bone flour will not do it: use only the flour from fresh, raw bones. Five barrels of this mixture to the acre is a cheap and most effective dressing for any kind of crops.

The cost of artificial fertilizers is based upon the amount of nitrogen, phosphoric acid, and potash they contain in available forms, and these have certain market values. Much of what is sold as superphosphate is really a mixture of several compounds, and is designed to serve the purpose of a general dressing for lands. Its value depends upon how much of the three essentials it holds; and in order to know what it is worth, first ascertain what it is made of, and then estimate from prices which

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are given upon the blackboard. At present a fair commercial price for

| | | |
|---|---|---|
| Nitrogen is . . . . . | 25 | cents per pound. |
| Soluble phosphoric acid, . . . | 10 | " |
| Potash, . . . . . | 5 | " |

The rectified guano, to which your attention has been called, contains, in one ton of 2,000 pounds,—

| | |
|---|---|
| 165 pounds nitrogen—25 cents, . . . . | $41.25 |
| 200 pounds soluble phosphoric acid—10 cents, . | 20.00 |
| 60 pounds reduced phosphoric acid—10 cents, . | 6.00 |
| 40 pounds potash—5 cents, . . . . . | 2.00 |
| | $69.25 |

A single ton of this is sold for $69.00, which is in close proximity to its true value. I place as high an estimate upon the value of the reduced phosphoric acid as upon the soluble, but it is usually regarded as less valuable, and is put at about six cents instead of ten. Whatever you are able to save from the above prices in purchasing and preparing your own fertilizers is so much to your advantage. The cost of the soluble phosphoric acid in the superphosphate, which is to be made in your presence to-day, will be a trifle over 7½ cents per pound, and this arises from the low prices of the raw materials used. Bone charcoal at $20 per ton, and oil of vitriol at $35, make the resultant superphosphate cost about $25 per ton, not estimating labor. Estimating the soluble phosphoric acid it contains at ten cents, the allowable value, and it is worth over $35 per ton. In the purchase of raw materials the quality and price are always to be considered, and the cheapest sources of supply are to be investigated.

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# SOILS AND THE GROWTH OF PLANTS.

BY PROF. LEVI STOCKBRIDGE, OF MASSACHUSETTS.

I apprehend that the expression "exhausted soil" is often used with little precision of meaning, and sometimes, perhaps, in ignorance of what constitutes the real difference between exhaustion and fertility. There is an important sense in which an exhausted soil is an impossibility. Plants are made up out of the material of the soil. Nearly all the soil, from its surface down to the bed-rock, however deep the mass may be, is capable, in answer to the action of natural law, of being transformed from the soil-form to the plant-form: therefore we cannot say that the soil is exhausted until the entire mass has passed through this transformation. Yet we have acres and acres of land which we know a hundred years ago were fertile; but to-day, although in its aggregate and in its general physical characteristics and appearance it remains as of old, it is, nevertheless, very sterile. There must, therefore, be a very marked distinction between soil in general, and fertility. Mr. A. owns large areas, leagues of land; and yet he possesses nothing of which he can immediately avail himself for the production of crops. And, again, Mr. B. is the owner of a very small area; but he owns something which will enable him at once to harvest the most bountiful crops.

Now, there is a great distinction, as I have already said, between soil and fertility. The question which I am to discuss this afternoon is really this difference between these two conditions of the land; and I shall necessarily be obliged, in discussing it, to speak somewhat of the composition and organism of plants, the composition and the changes of soil by which soil is

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converted into plants; and then, again, I must speak of the influence of the air and of the water in producing these changes, and the influence of the general growth of plants to the same end.

First, the plant. To me the living plant is always a wonder; to me there is something within the living, growing plant that is a profound mystery. And yet there is an aspect of this case in which we may say the plant is as well known as the building, in its structure and in its composition, is to the mechanic who has just erected it. The seed is to me a wonder, and it is to me, also, in some aspects, a profound mystery. Curious and wonderful is its formation. It is composed of two principal parts: first, the germ, which is a little plantlet, or more properly a plant in embryo, composed of roots, of stem, of bud, and of leaves. This is also surrounded by a little sack of cellular material, prepared by the parent plant as the food of the young plantlet before its own organs are able to gather food from the element in which it is located. Now the mystery of the thing is, that this little plantlet enclosed within the endosperm of the seed has within it the vital principle. It is alive, and, though apparently a dead thing, it will live on year after year, until there shall be a conjunction of all those circumstances which produce germination; and then it starts into active life.

Now, we go to work, and deposit this seed in the warm, moist soil. From the water of the soil it absorbs moisture, and expands. The oxygen of the air and the warmth cause this cellular mass, which we call the endosperm, to rot. It decays, it is taken to pieces (so far as the cellular mass is concerned), and separated into its constituent parts, dissolving in water; and then circulation and growth begin by the formation of cells, expansion takes place, cell is added to cell, cell to cell, until finally the organs by which the plant can supply its own food being developed, and the endosperm exhausted, it grows on with continued additions, enlarging, expanding, sending out new organs. And, if it be an annual plant, it throws out its blossom, perfects its seed, and dies; but if it be a perennial, like the acorn for instance, it makes its annual growth, enlarging and expanding year after year, and century after century, until finally the magnificent old oak of the forest stands before us, often of many tons

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weight. Now, then, in both these instances there has been a very large accumulation of matter from some source or other; but, mark you, there has been no new creation. The matter which was gathered and massed into this plant was matter as old as the morn of creation, and it has been simply passed through certain changes, been used by nature simply to build up the organism. But what is the matter? Whence is it? Those are the questions for us to answer.

Examine, now, this plant. Take the oak, if you please, to which I have alluded. Examine it with the naked eye; examine it under the microscope: and what do you find? Nothing that you ever saw before. There is nothing in it, nothing disclosed by the most powerful microscopic lens that you ever saw in the soil. Could it have come from the soil? No soil particles are visible; nothing that resembles the soil with which you have always been familiar. We are at a loss to know what it is. Supposing we bring in the chemist to make an examination, and he shall analyze this plant by fire, putting oxygen to work upon it, and we find by quick combustion that we have reduced it from its original condition; and now, if we were simply to weigh the ash, we should have in our crucible two pounds in weight out of every hundred of which the oak was originally constituted. Ninety-eight parts out of every hundred have taken on an invisible form, and disappeared. We have found nothing that resembles soil.

Go a single step further, and ask the chemist to take what we call the "ash," and apply his tests, and tell us what material it is, and whence it is. Applying his chemical tests to the ash, the chemist tells us, "Here is silica, here is potash, here is lime, soda, magnesia, phosphoric acid, sulphuric acid, chlorine, iron." We have not reached our point yet. Neither you nor I ever knew lime as lime in the soil; we never knew potash as potash in the soil. Although we are familiar with all these elements in the arts, yet we have never found them in the soil; and the question comes back, Whence this material that the plant has found which we call "ash"? And therefore we go to the soil, and see if we can find it there. A casual examination of the soil discloses this first. Here is a mass of fibrous and cellular material that seems to be in a decomposing or broken

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down condition. That, we conclude at once, must be the decaying materials which have come from the former growth of plants. Further than that, we find under the microscope that this soil is made up of small, broken, sometimes rounded, sometimes angular pieces of rock, similar to the rocks which are in our fields and in the country around us,—pieces of quartz, pieces of granite, of micaceous and talcose rocks, and of limestone rocks; but still we do not find anything like what we find in our crucible and call it ash.

Further careful examination discloses the fact that these particles of rock of which our soil is composed are distinct minerals. Here we find talc, we find mica, we find hornblende, we find felspar, we find calcite, magnesite, apatite, and phosphorite; but we have found neither lime, nor potash, nor soda, nor magnesia, nor anything which we find in the ash: we find simply distinct, well known minerals. Call on the chemist again. What says he? All these minerals are distinct, well known chemical compounds. They are not only particles of minerals which constitute rocks, but they are, away back and behind all that, distinct, well known chemical compounds. They are a union of silica, more generally of silicic acid, with lime, potash, soda, phosphoric acid, sulphuric acid, chlorine, &c. Now, then, we find at last that in a chemical form we have in the soil precisely the same materials that we find in the ash of the plant which we burned; and it is possible that although these minerals are as indestructible as the rocks, yet it is possible that this plant, somehow or other, contrived a way to draw lime, potash, and phosphoric acid out of the rocky materials of the soil. Let us, then, go back to the plant, and commence another examination.

The feeding organs of the plant, we read, are the leaves and the roots. We will examine first the leaves. Now this leaf is curiously and wonderfully made. First, it has a frame-work, which we call the ribs of the leaf. Through the centre, comparatively speaking, is one large timber, made of curiously compacted fibrous material, connected with the stem of the leaf, and by the stem with the cambium of the plant from which it grows; branching out on the right hand and the left are ribs or timbers of smaller dimensions, strongly built in all directions;

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and over the whole, both above and below, is drawn the epidermis, or skin cover, or coating, incasing and enclosing the framework of the leaf. Now, between the two, we find an open-work of cells,—cells that are cavities within the leaf, and yet are capable of holding air, gas, and water. Examining now the epidermal coating of the leaf, we find this curious fact, that every leaf is covered with a fine net-work of something which resembles hairs, and beneath that, or connected with it, a material which resembles wax, which completely, perfectly excludes from the inside of the leaf everything solid and everything liquid. Through that part, then, we know that nothing entered this leaf that was either in a solid or in a liquid state, because the surface of the leaf is perforated only by the most minute microscopic pores, so fine that on a single apple leaf there are hundreds of thousands of these little orifices entering from that to the cellular work within.

If this leaf, then, is one of the feeding organs of the plant,—and all leaves in this respect are alike,—if this leaf is one of the feeding organs of the plant, it has gathered nothing, it never can gather anything, it never can feed upon anything, but what is in the form of a gas; and thus, as we all know, carbonic acid gas, and perhaps carbonate of ammonia, taken through the leaf, is the food which the leaf gathers for the building up of the plant, and which was the ninety-eight per cent. of the weight of the oak wood which disappeared when we burned it in the fire. Ninety-eight per cent., then, of the weight of the oak, to speak in general terms, was gathered by the leaf out of the air in the form of gas, and the leaf had capacity to gather and take in nothing else. Nearly all the food of the plant, then, when taken up is simply gas.

Going now to the roots, the other feeding organs, we find here a very wonderful development. First are the trunk roots,—large, strong, similar in many respects to the trunk of the tree or the shrub itself; but, branching out in all directions in the soil, they become smaller and smaller, attenuated until they become simply a mass of fibrous, thread-like rootlets, following the surface of the soil for a long distance around every plant, and to very great depths; permeating, winding their way through, all its interspaces, apparently clinging to the small

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stones within the soil, and by their numberless root-hairs taking into and clasping in their embrace all the finer particles of soil. And what are these roots doing? What are they made for? What is their capacity to gather food, if they are feeding organs of the plant? Examine them under the microscope, and tell me what their work is, and how they perform it. Why, so far as we know, these millions of little rootlets that feed the plant are doing nothing but gathering water out of the soil: that is all they can do. There is nothing in the soil that they can do anything with but water: it is all that they can gather.

Now, then, is it pure water that the roots gather? Nothing ever entered their portals but in the form of water. Perhaps it is a solution. Let us take the water that the roots gather from the soil, and see what it is. Apply your chemical test to it, and it comes so near being pure water, that the most delicate tests can detect nothing, unless it is the most obscure trace of anything, but water; and if there is anything there, we must boil it down before we can determine with certainty what it is. Let it alone, and the plant will do this by root action, by capillary attraction, by osmose diffusion. I don't care by what name you call it, by some tremendous energy this water is thrown to the leaf, and there Nature boils it down. About ninety-five per cent. of all the water which goes up from the root is thrown out of the leaf into the air; about five per cent. remains in the leaf for the use of the plant. And in this wonderful leaf of which I have spoken now we find this union takes place: the five per cent. of water and carbonic acid taken from the air unite, and by the most delicate, the most wonderful, the most mysterious processes, within the plant.

With these two substances, water, and the carbon which has been taken out by the decomposition of carbonic acid, this plant will make all the organic substances, will make all the aroma of all your fruits and your flowers, will make all the gum, and all the starch, and all the sugar, and all the woody fibre which build up and make the great mass of the structure of your plants; and along with it, as it is deposited to build up the structure by the boiling-down process I have spoken of, or the reduction by throwing off the water, Nature will have deposited a little bit, the slightest possible quantity, of material taken out

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of the soil, and which it has carried and deposited in the plant which we find, and call "ash."

Now, then, this plant, so far as we know, has fed on two things, and only two,—the gas taken from the air by the leaf, and the water, which was the weakest possible solution, taken from the soil. There is nothing else the plant could take by either of these sets of organs; and the structure must be built up and composed of the material taken from the soil and the water by these organs in the forms I have mentioned. Now, then, if the plant did not find in the soil nor in the air the material necessary to build up its structure, and find it in the way here indicated (in the form of gas in the air, and the form of solution in the soil), the plant could not grow; and the distinctive difference between a soil fertile and a soil sterile is not that there is no lime in the soil, is not that there is no potash in the soil, because you might plant a potato-plant, which is a potash-plant, where it should send its rootlets down into felspathic sand, and it would die for the want of potash; or you might plant a wheat-plant on the soils of the Charleston basin, where it might send its rootlets directly down into the nodular phosphoric rocks of the basin, and yet it would die for want of phosphoric acid. The grand distinction, the only distinction, between soil fertility and soil sterility, is, not that there is not lime and potash and soda, and phosphoric acid and magnesia, in endless quantities, in the soil, but it is, that it is not soluble; and the distinction, the only distinction, between sterility and fertility, is solubility.

But the more important question to us, gentlemen, is, How can we make the materials for plant growth, contained in our granite soil in countless quantities, available for the use of plants? First, by the air. The air is a wonderful compound. Of course we are so familiar with the air that we count it of little worth. It is, nevertheless, a most wonderful mixture of certain important ingredients: First, oxygen; next, nitrogen, carbonic acid, ammonia, nitric acid, ozone. That is your air. One of these elements, the gas oxygen, is one of the most wonderful in the whole arcana of nature. It is primarily the oxygen of the air which takes to pieces and destroys everything that we know. All the monuments of man of every kind and descrip-



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tion,—of marble, of granite, of iron,—this one simple gas in the air will sooner or later take to pieces and crumble to dust. No power of ours, no skill of ours, will ever be able to resist its encroachments. This is the leading element in the air. The air has weight. I put it in that way for my purpose. The air has weight, and it penetrates the soil by expansion and contraction. Under the influence of daily changes of temperature the air enters the soil, and is expelled from the soil day by day, carrying in new quantities of the fertilizing elements, and new quantities of the oxygen.

Now, let us see what is the result. The oxygen of the air being carried into the soil oxidizes all the minerals or metals contained in it which I have just been enumerating. It finds calcium in the soil, and changes it to lime. It finds magnesium in the soil, and changes it to magnesia. It finds sodium in the soil, and changes it to soda. It finds iron, and changes it to the oxide. All these hard, impervious, insoluble materials are thus softened and made available under the influence of oxygen. But that is not all. This oxygen finds in the soil a particle of sulphur, unites with it, and you have oil of vitriol in the soil. It finds nitrogen, and, meeting with it in certain chemical proportions, you have nitric acid. It finds in the soil carbon, unites with it, and you have carbonic acid.

So you have made by the action of the oxygen of the air in the soil, first, oxides, and all the materials of food for the growth of your plant; and, next, you have the corroding, destroying acids, which now act in this way. Your potash, your soda, your lime, &c., which were in the soil, were more generally in the form of silicates. Lime, potash, soda, magnesia, united with silicic acid, which are as insoluble as yonder window-glass, are now touched with carbonic acid, and the lime leaves the silicic acid and goes to the carbonic acid, and so on; a great round of changes, each one of which wrings out of these silicates that we call the minerals of the soil,—wrings out of them lime, and potash, and soda, and phosphoric acid, and magnesia, which we find is the material which we call "ash" in the plant, and which by this process has been changed from insolubility to solubility, and becomes available for the plant, that its structure may be built up.

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But what has the plant to do with this? What has the plant to do with either sterility or fertility? Much every way. Now, whatever the mode of action, whatever may be the power and force of the air in converting this soil from its insoluble to its soluble condition, the living plant on the soil reënforces, strengthens, and increases it many fold. The rootlets of the living plant, working upon the surface of the particles of the soil, reënforce and strengthen, and make more powerful, all these other natural agencies. We place the plant upon the soil. Its rootlets permeate the whole surface, clinging to the particles by the root-hairs, incasing them, holding on to them,—and doing what? Gathering water; making a current of water, or increasing the force of that current which passes over the particles of the soil and thus removes a solution, giving place for another portion of the water to come from the soil beneath, and thus constantly keeping up a circulation of this material, removing it as formed, and depositing it in the plant above, so that the action of the oxygen and the action of the acids of the soil are reënforced and made more active and more potent by the root-action in the soil.

This process goes on during all the season of growth: when completed, then this plant, which gathered up this material as formed, and deposited it for the time being, as it were, in a reservoir within itself, dies, and carries it all back to the soil; and thus generation after generation of plants, growing on the same land, annually gather up and deposit the material, and annually carry it back to the soil; and thus the plant exerts its influence. In Nature's processes the plant is always an enriching element. I will not stop to apply this, gentlemen. Let me repeat it to make it strong. A plant on the land, in Nature's processes, is always an enriching element, carrying back all it gathers from the soil, and carrying with it that which it took from the air, which will exert sundry influences, both physical and chemical, upon the earthy materials of the soil itself. This process goes on, I say, year after year;—and here comes one of the wonders of creation. This earth has been drenched, and scored, and scarred, for I do not know how many tens of thousands of years, by falling water. And if He who made the soil had not provided some quality here, so that this material once prepared for the

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plant should be retained, this earth to-day would have been a scene of nought but desolation and sterility.

Therefore this soil, with its various properties, was made up in such a way, that when the action of the air and the action of the plant combined had developed and stored away in the plant large quantities of the proper material, and returned it to the soil, there it should remain, not washed away by the rain, not taken out of the soil and carried to the rivers and to the sea, but stored up, year after year, so that our soils become fertile,—simply magazines of proper plant-food, enough not only for one crop, but for very many crops when the circumstances of the case require us to gather plants and remove them. And thus the plant in its natural growth makes the soil richer year by year, so long as it may be permitted to continue in that condition. But, gentlemen, when man comes upon the scene, when he gathers plants from the soil that have been thus built up out of itself, and carries them away, there is an entire change of process. Every crop of plants you take from the land will carry away more material from the soil than is made by Nature in the same time. The power of the plant to gather food is superior to all the powers of Nature to make it out of the raw soil; and, if we remove the crops, there will every year be a diminution of the store or the quantity which Nature by her efforts had laid up for the use of plants.

Now, gentlemen, I am one of those who believe—and I dare state what I believe—that we have no soil in America that is stored so full of plant-food, that we have not here a climate which will develop out of the soil plant-food so fast, that constant culture and removal will not reduce it to sterility. I do not believe that our American soils, rich as they were originally, and of which we boast as being soils of exhaustless fertility, and of which we boast that we can feed the world by our crops,—I do not believe that we have any such soils. Your river-bottoms, that grow crops continually, are yearly manured, and therefore are not included in this case. But I say we have no soils from which we can take crops year by year without reducing them to sterility, for the very reason that has been stated,—the plant feeds faster than Nature can make food for it. I know, gentlemen, you will think of England. I know you will

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think of that wonderful series of experiments of Messrs. Laws and Gilbert, where they tell us that for thirty successive years their land has borne wheat, fourteen or sixteen bushels to the acre, on an average, without any diminution (and that is a paying crop); where they tell us that those lands for thirty odd years, without any manure, have borne them two tons and a half of hay to the acre, and for thirty odd years twenty bushels of barley to the acre. But I tell you those soils are not on this side of the Atlantic; and if that is the kind of soil they have in England, then I tell you the agricultural science of England is worth nothing to you or me. Our American soil and climate require an *American* science of agriculture. England can teach us nothing, if that is a sample of English soil.

I tell you that the science of agriculture in America is yet to be written. In my judgment we have not any. Why? Because we have not any facts. Where are the men to-day who are gathering the facts of American agriculture by thorough, tireless, exhaustive experiments? Nowhere. Let me tell you that never, in my judgment, will you have an American science of agriculture until you have that work going forward, painstaking, carefully, persistently, year after year. And we never shall learn how to manage our land by experiment under the foggy, damp, cold climate of England; but we must learn our facts in our bright, hot sunshine, the soil as it is, and the air as it is all around us. And we shall never be thoroughly and completely grounded where we ought to be, until we have a corps of men somewhere at work upon this all-important subject.

Now, then, I say (pardon me for this digression) that we have no soil in America that can be continually cropped, without at the same time being reduced in fertility,—growing poorer and poorer. And yet the water of the soil does not carry away appreciably any of the elements of fertility which are stored therein. Then, plants growing naturally on the soil enrich it. Plants growing on the soil by artificial culture always deplete it. We never can harvest crops from the land, and carry them away, unless, by some method or some scheme, we can contrive to develop out of the soil, by the aid of natural law, the materials we carry away, or else make direct application to the soil, in manurial form, of the materials we have removed.

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But again: What is the influence of water in the process? Much, every way. And this shall close my remarks, gentlemen. Think you that the soil of Utah is sterile? We talk about "the Great American Desert." Think you that that soil is sterile? Is the soil of Colorado sterile? Why, no. It is stored, to use a common expression, "chock-full" of the proper elements for the growth of plants, in a soluble condition and ready to be used; and yet those lands produce no crops. Why? Because they have not the water; that is all. Water applied to those soils has produced the results with which we are perfectly familiar, developing the most marvellous fertility; nothing but water. Water in Colorado, on a piece of apparently barren soil, will give you thirty or forty bushels of wheat to the acre, and do it year after year for quite a number of years. Water in Utah, on those barren soils, apparently sterile, will give you most bountiful crops of all those vegetables that you put on the land. Now, then, what water can do in Utah, what water can do in Colorado, in a certain sense water can do here. Have you not sandy lands which can be made fertile simply by the application of water? Certainly you have. Then the question comes, How does water act to make land more fertile? To see how water acts, I again ask your attention to the action of different kinds of plants. Plants are very peculiar in their structure and in their adaptation, according to their kind or variety. Let me illustrate: I put wheat upon a given field, and grow it year after year, and year after year, until it is so nearly exhausted that I cannot get a paying crop. It gives me five or six bushels of wheat to the acre. It does not pay, and I change it. I put on rye, and, where the wheat gave me six bushels to the acre, the rye gives me twelve, and that is a paying crop. Now, then, in their composition, rye and wheat are almost alike. The crop of twelve bushels of rye, with its straw, carried away from the land double the nitrogen, double the phosphoric acid, double the potash and lime, that the crop of wheat did. Pray tell me, how did it happen that this rye-crop got twice as much of those elements out of the soil as the wheat-crop could get? It was sterile for wheat; but the rye gathered the same materials, and it gathered double the quantity. To carry the illustration farther: I cultivate the rye until I cannot get more than five or

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six bushels to the acre. That won't pay. Therefore I put on the same land Indian corn. Now, what is the result? Why, on the land that gave me from five to seven bushels of rye, I shall get from fifteen to twenty-five bushels of Indian corn. Indian corn, the grain and its stalk, carried away from that land, of potash, phosphoric acid, and lime, four or five times as much as the rye. The rye could not get it. How happens it that this Indian corn plant has got so much more? I will tell you why,—and that is the point in relation to water. First, I will admit that one reason why the Indian corn plant got so much more is, that the Indian corn plant stayed on the land the longer time in the growing season;—but the more important reason was this: the root-expansion of the different plants,—that is the story,—the root-expansion, and the vital power and force and energy of the roots, of the different classes of plants. Let me illustrate this by the animal world. You turn into yonder brush pasture, covered with brambles and brakes, and all sorts of vile stuff of that kind, in which there is very little food of any value, a short-horn and a mule. The short-horn starves; the mule fattens. The short-horn cannot wring out of that coarse herbage the nutrition the mule can. It is the same material in both cases; but the vital power and force and energy, the digestive action, of the one animal, wrings from the soil the nutrition fitted for both, and the short-horn starves. It is precisely so with plants. Now, then, the Indian corn plant has a much larger root-expansion, has more vital force and energy, than either the rye or the wheat, and will gather out of that soil more of the elements of fertility; but a more important reason is, because its root-expansion pumps so much more water. The Indian-corn plant, as you know, sucks up thirty-six times its own weight of water in its season of growth,—largely more water than either wheat or rye; and this water from a larger area of soil, kept continually passing over the particles of soil, and taking off whatever solvent material it has, is carried into and deposited in the plant. Thus the Indian corn plant can wring out of the soil by its vital energy a greater quantity of water that it causes to pass over the particles of soil than can the wheat or rye plant, and become to you a paying crop.

One step more, gentlemen, and I will relieve you. What are

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you going to do about it? Well, I am going to do this about it. We have in Massachusetts, and you have here in New Hampshire, thousands and thousands of acres rich in the elements of plant-food. Neither we nor all who are to come after us can exhaust them. These old granite hills are rich in those materials of which plants are made. Neither we nor our descendants will ever be able to take them all out. The question is, How shall we develop them with the least possible expense to us, and with the greatest profit compared with the labor and the amount of crop we shall harvest?

First, I should say, Let the land go back to Nature. Kindly Nature will take care of it, and restore it to fertility; but we shall starve. We must grow crops that will make us food: therefore we must cultivate and carry the crops away. Now, then, I tell you that when we know what there is in the soil, when we know what Nature is doing to develop it, and when we know what the capacity of the plant is to wring nutrition out of it, sterility is an indication either of ignorance or of indolence; for we have no land that would not, if managed with proper intelligence and worked with a willing hand, return to us paying crops at a small cost of actual labor. I would make Nature help in the work. I would avail myself of every power and force that Nature exerts upon the soil to aid me in making plant-food in the soil, before I spent one dollar in the purchase of prepared plant-food with which to dress my land; and I would use plants as the first agent.

I have said nothing about clover. From what I say about Indian corn, you may imagine what I think of clover. I would take first, then, as an example, Indian corn on this land that will not bear more than fifteen bushels to the acre. That is a paying crop on that kind of land, because it costs nothing to till it. That crop I would harvest, carry it away, and feed it judiciously, intelligently, to the animals in my barn (and by "intelligently," I mean, to certain classes of animals), and the refuse of that crop I would give back to the land that produced it; and I would repeat the process; and then I would add to it clover, one of the best forage plants, and one of the best workers-up of the soil, that God has ever given to man. I would repeat it, I say, with Indian corn. I would then follow it with clover,

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spending the clover on the farm, and returning the refuse of the crop to the land; and if judiciously expended, with the right kind of stock, there would more material go back to the soil every year than was developed by Nature's process out of the soil; and by following that process, using the plant, using water wherever it can be obtained, we can make these lands bear crops as of old. But if the exigencies of the times require, if the markets of the country around us demand more, then, most assuredly, the material which we apply to the land must be the material which plants require, and in the very form in which they require it; and thus fertility will be the rule, and sterility will be the exception.

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# INSECTS AS FRIENDS TO MEN.

We are accustomed to consider insects only as pests, to be destroyed in the most speedy and effective manner. They feed on the seed we place in the soil; they consume the tender germ, and cut down the growing blade; they revel in the opening flower, or blight and ruin the ripening fruit; they burrow in the meadows, feeding on the roots of grass and grain, and change a promised harvest into dried and crippled leaf and stalk; they attack the forest, and cause destruction amid its most vigorous growth; they make their home in the choice selections of the garden and the park, and withered leaves and broken branches follow; they fill the air with their multitudinous forms, and annoy both bird and beast; they torment and poison even man, and cause painful disease and final death.

There is no evil of which they appear to be wholly innocent, in the view which we are naturally inclined to take of them.

But there is another side, seen by science and art, which commends them to our admiration, and to our care and protection. It is presented in the accompanying paper, copied from the Gentleman's Magazine, an English publication of rare merit. It is entitled,

## OUR DEBT TO INSECTS.

By Grant Allen.

It has often occurred to me as a curious fact, when I have been watching the bees and butterflies in an English meadow of a summer morning, that no one should ever yet have adequately realized the full amount of human indebtedness to those bright and joyous little winged creatures. I do not mean our practical indebtedness to insects for honey and bees'-wax, silk and satin, cochineal and lacquer, or a hundred other such-like useful products: these, indeed, are many and valuable in their own way,

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though far less so than the tribute we draw from most of the other great classes of animal life. But there is one debt we owe them so out of all proportion to their size and relative importance in the world, that it is strange it should so seldom meet with due recognition. Odd as it may sound to say so, I believe we owe almost entirely to insects the whole presence of color in nature, otherwise than green. Without them our world would be wanting in more than half the beautiful objects which give it its greatest æsthetic charm in the appreciative eyes of cultivated humanity. Of course, if insects had never been, the great external features of the world would still remain essentially the same. The earth sculpture that gives rise to mountains and valleys, downs and plains, glens and gorges, is wholly unconnected with these minute living agents; but all the smaller beauties of detail which add so much zest to our enjoyment of life and nature would be almost wholly absent, I believe, but for the long-continued æsthetic selection of the insect tribes for innumerable generations. We have all heard, over and over again, that the petals of flowers have been developed mainly by the action of bees and butterflies,—and as a botanical truth this principle is now pretty generally accepted; but it may be worth while to reconsider the matter once more from the picturesque and artistic point of view by definitely asking ourselves, How much of beauty in the outer world do we owe to the perceptions, and especially to the color-sense, of the various insects?

If we could suddenly transplant ourselves from the gardens and groves of the nineteenth century into the midst of a carboniferous jungle on the delta of some forgotten Amazon or some primeval Nile, we should find ourselves surrounded by strange and somewhat monotonous scenery, very different from that of the varied and beautiful world in which we ourselves now live. The huge foliage of gigantic tree-ferns and titanic club-mosses would wave over our heads, while a green carpet of petty trailing creepers would spread luxuriantly over the damp soil beneath our feet. Great swampy flats would stretch around us on every side; and, instead of the rocky or undulating hills of our familiar Europe, we should probably see the interior country composed only of low ridges, unlifted as yet by the slow upheaval of ages into the Alps or Pyrenees of the modern continent. But the

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most striking peculiarity of the scene would doubtless be the wearisome uniformity of its prevailing colors. Earth beneath and primitive trees overhead would all alike present a single field of unbroken and unvarying green. No scarlet flower, golden fruit, or gay butterfly would give a gleam of brighter and warmer coloring to the continuous verdure of that more than tropical forest. Green, and green, and green again: wherever the eye fell it would rest alike upon one monotonous and unrelieved mass of harsh and angular verdure.

On the other hand, if we turn to a modern English meadow, we find it bright with yellow buttercups and purple clover, pink-tipped daisies and pale-faced primroses. We see the hedges white with may or glowing with dog-roses. We find the trees overhead covered with apple-blossom or scented with horse-chestnut. While in and out among the beautiful flowers flit equally beautiful butterflies—emperors, admirals, peacocks, orange-tips, and painted ladies. The green of the grassy meadow and the blue of the open sky serve only as back-grounds to show off the brighter hues of the beautiful blossoms, and the insects that pay court to them incessantly.

To what is this great change in the general aspect of nature due? Almost entirely, we may now confidently conclude, to the color-sense in the insects themselves. The lovely tints of the summer flowers and the exquisite patterns on the butterfly's wings have alike been developed through the taste and the selective action of these humble little creatures. To trace up the gradual evolution of the insect color-sense and its subsequent reactions upon the outer world, we must go back to a time when neither flower nor butterfly yet existed.

In the carboniferous earth we have reason to believe that almost all the vegetation belonged to the flowerless type—the type now represented among us by ferns and horse-tails. These plants, as everybody knows, have no flowers, but only spores or naked frondlets. There were a few flowering plants, it is true, in the carboniferous world, but they belonged entirely to the group of conifers, trees like the pines and cycads, which bear their seeds in cones, and whose flowers would only be recognized as such by a technical botanist. Even if some stray archaic members of the true flowering groups already existed, it

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is, at any rate, almost certain that they must have been devoid of those gay petals which distinguish the beautiful modern blossoms in our fields and gardens.

A flower, of course, consists essentially of a pistil or seed-producing organ, and a certain number of stamens or fertilizers. No seed can come to maturity unless fertilized by pollen from a stamen. But experience, and more especially the experiments of Mr. Darwin, have shown that plants produced from the pollen of one flower applied to the pistil of another are stronger and more vigorous than plants produced from the stamens and ovules of a single blossom. It was to obtain the benefit of this cross-fertilization in a simple form that flowers first began to exist; their subsequent development depends upon the further extension of the same principle.

The pines and other conifers, the grasses and sedges, and the forest trees, for the most part depend upon the wind to waft the pollen of one blossom to the pistil of the next. Hence their flowers generally protrude in great hanging masses, so that the breeze may easily carry off the pollen, and that the pistils may stand a fair chance of catching any passing grain. Flowers of some such types as these were doubtless the earliest of all to be evolved, and their colors are always either green or plain brown.

But wind fertilization is very wasteful. Pollen is an expensive product to the plant, requiring much useful material for its manufacture; and yet it has to be turned loose in immense quantities on the chance that a stray grain here and there may light upon a pistil ready for its reception. It is almost as though the American farmers were to throw their corn into the Atlantic in hopes that a bushel or two might happen to be washed ashore in England by the waves and the Gulf Stream. Under such circumstances, a ship becomes of immense importance; and Nature has provided just such ships, ready made for the very work that was crying out to them. These ships were the yet undifferentiated insects, whose descendants were to grow into bees, rose-beetles, and butterflies.

Already, in the carboniferous world, winged insects had begun to exist. Some of these must soon have taken to feeding among the hanging blossoms of the first flowering plants. Insects are fond of the soft and nutritious pollen; and it would seem at first

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sight as though they could therefore be only enemies to the plants which they visited. But as they went from flower to flower in search of food, they would carry pollen from one to the other, clinging to their heads, feet, or legs, and so would unconsciously aid in fertilizing the blossoms. Though some of the pollen would thus be eaten up, yet the saving effected by the substitution of the insect as a ship, for the old wasteful mode of dispersal by the wind, would more than compensate for the loss thus brought about. Accordingly, it would naturally happen that those flowers which most specialized themselves for fertilization by means of insects would gain a considerable advantage over their neighbors in the struggle for existence. For this purpose, their outer leaves ought to assume a cup-like shape, instead of the open clusters of the wind-fertilized type; and their form should be directed rather to saving the pollen than to exposing it; while their efforts must chiefly be expended in attracting the insects whose visits would benefit them, and repelling all others. Those flowers which chanced to vary most in these directions would best succeed from generation to generation; and their descendants would finally become so modified as to be fitted for fertilization by insects only.

It would be needless here to allude once more to the changes in shape and arrangement thus brought about by the action of the insects. The attraction of perfume and honey, the devices of adaptation and modification, by which plants allure or detain their insect visitors, must be taken for granted, and we must pass on to our proper subject of color.

If, when insects were first beginning to visit flowers, there was any special difference by which the pollen-bearing parts could be easily distinguished from the other organs of the plant, we may be sure that it would be seized upon by the insects as a guide to the existence of food, and would be so further strengthened and developed in all future plants of the same species. Now, we have reason to believe that just such a primitive difference *does* exist between flowers, and leaves or stems; and *that* difference is one of color. Even if we look at the catkins and grass-blossoms of our own day, we see that they differ slightly in hue from the foliage of their respective plants. But it seems not improbable that color may have appeared much more fre-

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quently and abundantly in *primitive* wind-fertilized flowers than in those of our own epoch,—because wind-fertilized flowers are only injured by the visits of insects, which would be attracted by bright color; and hence natural selection would tend to keep down the development of brilliant tints in them, as soon as these had become the recognized guides of the insect eye. In other words, as flowers have now split up, functionally speaking, into two great groups, the wind-fertilized and the insect-fertilized, any primitive tendency toward the production of bright leaves around the floral organs will have been steadily repressed in the one group and steadily encouraged in the other.

Did such a primitive tendency ever exist? In all probability, yes. The green parts of plants contain the special coloring matter known as chlorophyl, which is essential to their action in deoxidizing the carbonic acid of the atmosphere. But, wherever fresh energies are being put forth, the reverse process of oxidation is going on; and in this reverse process the most brilliant and beautiful colors make their appearance. We are all familiar with these colors in autumn leaves; and we may also observe them very conspicuously in all young shoots or growing branches, especially in the opening buds of spring, the blanched heads of rhubarb or seakale, and the long sprays of a sprouting potato grown in a dark cellar. Now, the neighborhood of the floral organs is just such a place where energies are being used up and where color is therefore likely to appear. Mr. Sorby has shown that the pigment in petals is often exactly the same as that in the very young red and yellow leaves of early spring and the crimson foliage of autumn, in the same plant. It would be impossible to go fully here into the evidence which might be offered on this head. An immense mass of facts shows us that color is always tending to appear in the leaves which immediately surround the floral organs, and that this tendency has been strengthened by insect selection of the most conspicuous blossoms, until it has finally resulted in the brilliant corollas of such flowers as those which we now cultivate in our modern gardens.

But all this takes for granted the very fact with which we are now concerned, the existence and growth of an insect color-sense. How do we know that insects can distinguish colors at all? For otherwise all this argument must be fallacious, and

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the presence of bright corollas must be due to some other cause.

Of all insects, bees are the most confirmed flower-haunters, and they have undergone the greatest modification in relation to their visits in search of honey. We might expect, therefore, that bees would exhibit a distinct color-sense; and this is actually the case. Sir John Lubbock's experiments clearly prove that bees possess the power of distinguishing between red, blue, green, and yellow. Being anxious to see whether insects were really attracted by the hues of flowers, he placed slips of glass, smeared with honey, on paper of various colors; and the bees upon which he experimented soon learned to return to one particular color only, even though both the paper and the honey were occasionally transposed. Thus we have direct evidence of the clearest sort that the higher insects *do* actually perceive the difference between various colors. Nay, more, their perception in this respect appears to be closely analogous to our own; for, while the bees had no difficulty in discriminating between red, orange, or yellow, and green, they did not seem to perceive so marked a distinction between green and blue. Now, this fact is very like that which we perceive to hold good with the human eye, for all of us are much more likely to confuse green and blue than any two other hues.

If, then, bees and wasps, as Sir John Lubbock has shown, and butterflies, as we may infer from other observations, *do* possess this developed color-sense, we may ask, How did they obtain it? In all probability it grew up side by side with the growth of bright-hued flowers. Just as those blossoms which exhibited the greatest tendency to display a brilliant whorl of tinted leaves, in the neighborhood of their stamens and pistils, would best succeed in attracting insects, so, in return, those insects whose eyes were most adapted for distinguishing the pink and yellow blossoms from the green foliage would best succeed in procuring food, and would thus live down their less gifted competitors.

It may reasonably be asked, How could an animal without a color-sense develop such a faculty by the aid of natural selection alone? At first sight the question seems indeed a difficult one; but it is possible, I think, to suggest a way in which it may have



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happened. Colors, viewed objectively, consist of ether-waves having different rates of vibration. In an eye devoid of the color-sense, all these ether-waves would doubtless set up the same sort of action in all the ends of the nerves, and would therefore produce exactly the same general sensations. But if in certain eyes there was the slightest tendency for some of the nerve-terminals to respond specially to the oscillations of one particular order, while others of the nerve-terminals responded rather to oscillations of a different order, there would be the first groundwork for the evolution of a color-sense. If this diversity of action in the nerve-ends proved of no service to the animal, it would go no further, because those individuals who possessed it would not be favored beyond those who did not. But if it proved useful, as it undoubtedly would do to the flower-haunting insects, natural selection would insure its survival, and its constant increase from generation to generation. Even color-blind people among ourselves can be taught, by care and attention, to discriminate slightly between the hues which they at first confuse; and if we were to choose out, time after time, from a color-blind race, all those individuals who were best able to see these distinctions, we should, no doubt, at last succeed in producing a perfect color-sense. This is just what natural selection seems to have done in the case of bees and butterflies.

Yet it may be urged that insects perhaps had a color-sense *before* they began to haunt flowers, and that this sense enabled them to pick out the brighter blossoms from the very beginning. Such an hypothesis would make the origin of beautiful flowers a much more simple matter; but we can hardly accept it, for a very good reason. Before the existence of flowers there was probably nothing upon which insects could exert a color-sense. Now, we know that no faculty ever comes into existence until it is practically of use to its possessors. Thus, animals which always live fixed and immovable in one place, never develop eyes, because eyes would be quite useless to them; and even those creatures which possess organs of vision in their young and free state lose them as soon as they settle down for life in a permanent and unchangeable home. So, unless insects had something to gain by possessing a color-sense, they could never get one, prophetically, so to speak, against the contingency of

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flowers at some time or other appearing. Of course, no creature would develop such a sense merely for the sake of admiring the rainbow and the sunset, or of observing gems and shells or other such bright-hued but useless bodies. It is in the insect's practical world of food-hunting and flower-seeking that we must look for the original impulse of the color-sense.

Again: Throughout the whole animal world, we see good reasons for concluding that, as a matter of fact, and apart from such deductive reasoning, only those species exhibit evident signs of a color-sense to whom its possession would be an undoubted advantage. Thus, in this very class of insects, bees, as Sir John Lubbock's experiments show us, do undoubtedly distinguish between red, orange, yellow, and green. Butterflies also are attracted by colors, and will, in particular, fly down to objects of the same hue as their own mates. Of course, bees and butterflies, always living among flowers, especially require a good sense of color; and so they quite accord with our expectation. Wasps, again, are omnivorous creatures, living partly upon animal and partly upon vegetable food. Everybody knows that they will quite impartially feast upon a piece of raw meat or upon the sunny side of a peach. Now, wasps, as Sir John Lubbock proved, can also distinguish colors; but they are somewhat less guided by them, apparently, than are bees; and this again bears out the same generalization. Ants are much more miscellaneous in their diet; they have no wings (roughly speaking), and they do not visit flowers except by the casual process of walking up the stems. Hence a color-sense would be of little or no use to them: and Sir John Lubbock's experiments seem to show that they scarcely possess one, or only possess it in a rudimentary form. Once more: Moths fly about in the dusk, or quite at night, and the flowers which lay themselves out to attract them are white or pale yellow, since no others are visible in the evening. Thus, a perception of red, blue, or orange would probably be useless to them: and Mr. Lowne has shown that the eyes of nocturnal insects differ from those of diurnal insects in a way closely analogous to that in which the eyes of bats and owls differ from those of monkeys and humming-birds. These differences are probably connected in both cases with an absence of special organs for discriminating colors; and we shall see, a

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little later on, that, while the day-flying butterflies are decked in crimson and orange to please the eyes of their fastidious mates, the night-flying moths are mostly dull and dingy in hue, or reflect the light only in the same manner as the night-flowering blossoms among which they seek their food. Ascending to the vertebrates, the birds are the class which live most in a world of fruits or flowers; and Mr. A. R. Wallace has pointed out that birds, on the whole, need to perceive color more than any other animals, because their habits require that they should recognize their food at a considerable distance. But birds possess a very large proportion of certain nerve-terminals called the cones, which are three times as numerous in their eyes as the other kind called rods. These cones are almost universally believed to be the special organs of color-perception, and in mammals they are actually *less* numerous than the rods, which are supposed to be merely cognizant of light and shade. Nocturnal birds, such as owls, have very few cones, while nocturnal mammals have none. Again: The yellow spot in the retina, consisting almost entirely of cones, is found in all diurnal birds; but among mammals it occurs only in the fruit-eating class of monkeys, and in man. So that on the whole we may say the positive evidence justifies us in believing that a highly-developed color-sense exists only in those animals which would be decidedly benefited by its possession. And for these reasons it seems improbable that insects ever developed such a faculty until the need for it arose among the beautiful flowers.

Now that we have arrived at this theoretical conclusion, let us hark back again for a while to the reactions which the color-sense, thus aroused, produced upon the flowers which gave it birth.

We may take, as a capital example of an insect-fertilized flower, an English dog-rose. Compare this mentally with the wind-fertilized blossoms, such as grasses and catkins, and it is at once obvious that the great difference between them consists in the presence of a colored corolla. No wind-fertilized plant ever has a whorl of gay petals; and though the converse is not quite true, yet almost all insect-fertilized plants are noticeable for their brilliant tints of red, white, blue, or yellow. The structures in which these pigments reside have no function what-

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soever, except that of attracting the insect eye. They are produced by the plant at an enormous physiological expense; and, if their object were not to secure the visits of insects, they would be just so much dead loss to the species. Nor is it only once that these colored corollas have been developed. They occur, quite independently, in both great divisions of flowering plants, the monocotyledons and the dicotyledons. This coincidence could hardly have happened had it not been for that original tendency which we already noticed for pink, scarlet, or orange pigments to appear in the neighborhood of the floral organs. Nor is it twice only, in all probability, that flowers have acquired bright petals through insect visits, but a thousand times over. In almost every family, insect-fertilized, self-fertilized, and wind-fertilized species are found side by side, the one with brilliant petals, the others with small, green, and inconspicuous flowers.

For comparison with the dog-rose, one could not find a better type than that common little early spring blossom, the dog's mercury. It is a wind-fertilized flower, and it does not wish to be seen of insects. Now, this mercury is a very instructive example of a degenerate green flower. For, apparently, it is descended from an insect-fertilized ancestor with bright petals; but, owing to some special cause, it has taken once more to the old wasteful habit of tossing its pollen to the wandering winds. As a consequence it has lost the bright corolla, and now retains only three green and unnoticeable perianth-pieces, no doubt the representatives of its original calyx. Almost equally instructive is the case of the groundsel, though in this case the process of degradation has not gone quite so far. Groundsel is a degenerate composite, far gone on the way of self-fertilization. No class of flowers have been more highly modified to suit the visits of insects than the composites. Hundreds of their tubular bells have been crowded on to a single head, so as to make the greatest possible attractive display; and in many cases the outer blossoms of the head, as in the common yellow ragwort, or in the daisy and the sunflower, have been flattened out into long rays, which serve as pennants or banners to catch the insect eye. They are very successful flowers, perhaps the most successful family on the whole earth. But the groundsel, for some

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reason of its own, has reversed the general family policy. It is rarely visited by insects, and has, therefore, apparently taken once more to self-fertilization; and a complete alteration has thus been effected in its appearance, when compared with its sister composites. Though it has not yet quite lost its yellow centre blossoms, it has no rays, and its bells are almost concealed by its large and ugly green involucre. Altogether, we may say that groundsel is a composite far advanced on its way to a complete loss of the characteristic composite habits. It still receives the visits of a very few stray insects, but it does not lay itself out to court them, and it is, probably, gradually losing more and more of its winged clients from day to day. Thus we see that any flower which will benefit by insect-fertilization, whether it be a monocotyledon or a dicotyledon, high up or low down in either series, is almost sure to acquire brilliant petals; while, on the other hand, any flower which gives up the habit of relying upon insects is almost sure to lose or minimize its petals once more, and return to a state resembling in general type the catkins and grasses, or the still lowlier self-fertilized types.

The same sort of conclusion is forced upon us if we look at the various organs in each flower which display the brilliant pigments. The petals are most commonly the seat of the attractive coloration, as in the dog-rose and the marsh-mallow. But in many other flowers, like the fuchsia, the calyx is also beautifully colored, so as to aid in the general display. In the tulips and other lilies, the crocus, the iris, and the daffodil, sepals and petals are all colored alike. In marvel-of-Peru and purple clematis, the petals are wholly wanting. In the common meadow-rue it is the essential floral organs themselves which act as allurements; while, in the mesembryanthemums, the outer stamens become flattened and petal-like, so as to resemble the corolla of other flowers. In the composites, like daisies, where many blossoms are crowded on one head, the outer row of blossoms is often similarly flattened into rays, which only serve the purpose of attracting insects toward the fertile flowers of the centre. Nor does the coloring process stop at the regular parts of the flower alone: the neighboring bracts and leaves are often even more beautifully tinted than the flowers themselves. In the great white arums, grown in windows as Ethiopian lilies,

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the actual blossoms lie right inside the big sheath or spathe, and cluster round the tall yellow spike or spadix in the centre: and this sheath acts the part of petals in the more ordinary flowers. Many euphorbias have very inconspicuous little blossoms, but each small colony is surrounded by a scarlet involucre, which makes them some of the gayest among our hot-house plants. The poinsettia, which is so familiar a fashionable dinner-table plant, bears little yellow flowers which would not of themselves attract the eyes of insects; but it makes up for this deficiency by a large surrounding bunch of the richest crimson leaves, whose gorgeous coloring makes the tree a universal favorite with tropical bees and butterflies. The lovely bougainvillea carries the same idea one step further, for its small flowers are inclosed by three regularly arranged bracts of a delicate mauve or pink; and when one sees a tree covered with this magnificent creeper in full blossom, it forms one of the most glorious masses of color to be found in the whole of external nature. Many tropical plants, and especially those of parasitical habit, are much given to developing these extra allurements of colored leaves. and their general effect is usually one of extreme brilliancy. From all these examples we can draw the conclusion that color does not belong by original nature to one part of the plant rather than another; but that wherever the colored juices which result from oxidation of chlorophyl and its analogues began to show themselves, in the neighborhood of the stamens and pistil, they would attract the attention of insects, and so grow more and more prominent, through natural selection, from generation to generation, till they finally attained the present beauty of the tulip, the rose, the poinsettia, and the bougainvillea.

From this marvellous reaction of the color-sense in insects upon the vegetal world, we must next pass on to its reaction upon the hues of insects themselves. For we probably owe the exquisite wings of the butterfly and the gorgeous burnished bronze of the rose-beetle to the very same sense and the very same selective action which have produced the hues of the lily and the hyacinth. What proofs can be shown that the colors of insects are thus due to sexual selection? In the first place, we have the certain fact that bees, at least, and probably other

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insects, do distinguish and remember colors. Not only so, but their tendency to follow color has been strong enough to produce all the beautiful blossoms of our fields and gardens. Moreover, we have seen that while bees, which are flower-haunters, are guided greatly by color, wasps, which are omnivorous, are guided to a less extent, and ants, which are very miscellaneous feeders, not at all. It may be objected that insects do not care for the color apart from the amount of honey; but Mr. Anderson noticed that, when the corollas of certain flowers had been cut away, the insects never discovered or visited the flowers; and Mr. Darwin lopped off the big lower petals of several lobelia blossoms, and found that the bees never noticed them, though they constantly visited the neighboring flowers. On the other hand, many bright-colored bells have no honey, but merely make a great show for nothing, and so deceive insects into paying them a call in the delusive expectation that they will be asked to stay to dinner. Some very unprincipled flowers, like the huge Sumatran rafflesia, thus take in the carrion-flies, by resembling in smell and appearance a piece of decaying meat. Moreover, certain insects show a preference for certain special flowers over others. One may watch for hours the visits paid by a bee or a butterfly to several dozens of one flower, say a purple lamium, in succession, passing by unnoticed the white or yellow blossoms which intervene between them. Fritz Müller mentions an interesting case of a lantana, which is yellow on the first day, orange on the second, and purple on the third. "This plant," he says, "is visited by various butterflies So far as I have seen, the purple blossoms are never touched. Some species inserted their proboscides both into yellow and into orange flowers; others, as far as I have observed, exclusively into the yellow flowers of the first day." Mr. T. D. Lilly, an American naturalist, observed that the colored petunias and morning-glories in his garden were torn to pieces by bees and butterflies in getting at the honey, while the white or pale ones were never visited. These are only a few sample cases out of hundreds, in which various observers have noted the preference shown by insects for blossoms of a special color.

Again, we may ask, Do different species of insects show different degrees of æsthetic taste? The late Dr. Hermann

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Müller, who specially devoted himself to the relations between insects and flowers, showed most conclusively that they do. The butterflies, which are at once the most locomotive and most beautiful of their class, appear to require larger masses of color for their attraction than any other group; and the flowers which depend upon them for fertilization are, in consequence, exceptionally large and brilliant. Müller attributes to this cause the well-known beauty of Alpine flowers, because bees and flies are comparatively rare among the higher Alps, while butterflies, which rise to greater elevations in the air, are comparatively common; and he has shown that, in many cases, where a lowland flower is adapted for fertilization by bees, and has a small or inconspicuous blossom, its Alpine congener has been modified so as to be suited for fertilization by butterflies, and has, therefore, brilliant bunches of crimson or purple blossoms. In his last work, he shows that, while bees form as many as seventy-five per cent. of the insects visiting the beautiful and attractive composites, they form only fourteen per cent. of those which visit the plain green and white umbellates, like the wild-carrot and fool's-parsley. Butterflies frequently visit the composites, but almost never the umbellates, which last depend mainly upon the smaller flies and other like insects. Of two small hedge-flowers (*Galium mollugo* and *G. verum*), Müller notes that they agree closely in other points, but the first is white, while the second is yellow, which, he says, renders it more attractive to small beetles. Of certain other flowers, which lay themselves out to attract wasps, Müller quaintly observes that they are obviously adapted "to a less æsthetically cultivated circle of acquaintances." So that the close studies of this accurate and painstaking naturalist led him to the conclusion that insects differ greatly from one another in their taste for color. Probably we shall be right if we say that the most æsthetic among them all are the butterflies, and next the bees—these two classes having undergone the most profound modifications in adaptation to their flower-haunting life—and that the carrion-flies and wasps bring up the rear.

Is there any evidence, however, that insects ever notice color in anything else but flowers? Do they notice it in their own mates, and use it as a means of recognition? Apparently they

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do, for Mr. Doubleday informed Mr. Darwin that white butterflies often fly down to pieces of white paper on the ground, mistaking them doubtless for others of their species. So, too, Mr. Collingwood notes that a red butterfly, let us say, nailed to a twig, will attract other red butterflies of the same kind, or a yellow one its yellow congeners. When many butterflies of allied species inhabit the same district, it often happens that the various kinds undergo remarkable variation in their coloring so as to be readily recognizable by their own mates. Again: Mr. Patterson noticed that certain blue dragon-flies settled in numbers on the blue float of a fishing-line, while two other species were attracted by shining white colors. On the whole, it seems probable that all insects possessing the color-sense possess also a certain æsthetic taste for colors.

Indeed, it is difficult to see how it could be otherwise. Whenever an animal exercises a faculty much, the exercise comes to have pleasant feelings attached to it; and this is especially the case with all sense-organs. Creatures which live on honey love sweet things: carnivores delight in the taste of blood. Singing birds listen with interest to musical notes, and even insects will chirp in response to a chirp like their own. So, creatures which pass all their lives in the search for bright flowers must almost inevitably come to feel pleasure in the perception of brilliant colors. This is not, as so many people seem to think, a question of relative intellectual organization: it is a mere question of the presence or absence of certain sense-centres.

But it may finally be urged, that even though insects recognize and admire colors in the mass, they would not notice such minute and delicate patterns as those on their own wings. Let us see what evidence we can collect on this head. First of all, insects have not only produced the petals of flowers, but also the special markings on those petals. Now, these markings, as Sprengel pointed out a century since, bear a constant reference to the position of the honey, and are in fact regular honey-guides. If one examines any flower with such marks upon the petals, it will be found that they converge in the direction of the nectaries, and show the bee or butterfly whereabout he may look for his dinner. Accordingly, they must have been developed by the gradual action of insects in fertilizing most frequently those

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flowers which offered them the easiest indication of where to go for food. Unless insects noticed them,—nay, more, noticed them closely and accurately,—they could never have grown to their present definite correlation with the nectary, a correlation which, Mr. Darwin says, first convinced him of the reality of their function. "I did not realize the importance of these guiding marks," says Sir John Lubbock, "until by experiments on bees I saw how much time they lose if honey which is put out for them is moved even slightly from its usual place." In short, insects, like men, are creatures of habit. How complicated these marks sometimes become, we can see in most orchids.

Again: The attention insects pay to comparatively small details of color and form is clear enough from the *mimicry* which sometimes occurs among them. In some instances, the mimicry is intended to deceive the eyes of higher animals, such as birds or lizards, and can therefore prove nothing with regard to the senses of the insects themselves. But, in a few cases, the disguise is adopted for the sake of deceiving other insects; and the closeness of the resemblance may be accepted as good evidence of acute vision in the class so mimicked. Thus, several species of flies live as social parasites among the hives or nests of bees. These flies have acquired belts of color and patches of hair, closely imitating the hosts whose honey they steal; while their larvæ have even the ingratitude to devour the larvæ of the bees themselves. Of course, any fly who entered a bee-hive could only escape detection and condign punishment at the hands—or rather at the stings—of its inhabitants, provided it looked so like the householders as to be mistaken by them for one of the community. So any fly which showed at first any resemblance to a bee would for a while be enabled to rob with impunity; but, as time went on, the bees would begin to perceive the true nature of the intruders, and would kill all those which could be readily distinguished. Thus, only the most bee-like flies would finally survive; and the extent to which the mimicry was carried would be a rough test of the perceptive powers of the bees. Now, in these particular cases, the resemblance is so close that it would take in, not only an unpractised human observer, but even for a moment the entomologist himself. Similar instances occur among *Mantidæ* and crickets.

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And now let us apply these facts to the consideration of the problem before us. If those insects which especially haunt flowers are likely to have so acquired a color-sense and a taste for colors, and if they are capable of observing minute markings, bands, or eye-like spots, then we might naturally infer that they would exhibit a preference for the most beautifully colored and variously ornamented of their own mates. Such a preference, long continued and handed down to after-generations, would finally result in the development of very beautiful and varied colors among the flower-haunting species. We might expect, therefore, to find the most exquisite insects among those races which are most fully adapted to a diet of honey and pollen; and such I believe to be actually the case.

Before proceeding further, precautions should be taken against a misconception which has already occurred in this connection. It is not meant that bright colors will be found *only* among flower-haunters, for it may easily happen that in a few instances other causes may conspire to produce brilliant hues. Nor is it meant that *all* flower-haunters are necessarily brilliant; for it may also happen that some special need of protection will occasionally keep down the production of conspicuous tints. But what *is* meant is, that brilliant colors are found with very exceptional frequency among the specially flower-haunting animals.

Butterflies are the order of insects which require the largest mass of color to attract them, and which seem to possess the highest æsthetic sensibility. It is hardly necessary to say that butterflies are also the most beautiful of all insects; and are, moreover, noticeable for the most highly developed ornamental adjuncts. Those butterflies make the best matches in their world of fashion which have the brightest crimson on their wings or the most exquisite gloss in their changeful golden scales. With us, an eligible young man is too often a young man with a handsome estate in the country, and with no other attractions, mental or physical. Among insects, which have no estates, an eligible young butterfly is one with a peculiarly deep and rich orange band upon the tip of his wings. Thus the cumulative proof of the æsthetic superiority of butterflies seems well-nigh complete.

If we examine the lepidoptera or butterfly order in detail, we

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shall find some striking conclusions of the same sort forced upon us. The lepidoptera are divided into two great groups, the moths and the butterflies. Now, the moths fly about in the dusk or late at night: the flowers which attract them are pale, lacking in brilliancy, and, above all, destitute of honey-guides in the shape of lines or spots; and the insects themselves are generally dark and dingy in coloration. Whenever they possess any beauty of color, it takes the form of silvery scales which reflect what little light there may be in the gray gloaming. The butterflies, on the other hand, fly by day, and display, as we know, the most beautiful colors of all insects. Here we must once more recall that difference between the structure of the eye in nocturnal and diurnal species which Mr. Lowne has pointed out. Nor is this all. While most moths are night-fliers, there are a few tropical genera which have taken to the same open daylight existence as the butterflies. In these cases, the moths, unlike their nocturnal congeners, are clad in the most gorgeous possible mixtures of brilliant metallic colors.

Other instances of like kind occur in other orders. Thus, among the beetles, there is one family, the rose-chafers, which has been specialized for flower-haunting; and these are conspicuous for the beauty of their coloring, including a vast number of the most brilliant exotic species. Their allies, the common cock-chafers, however, which are not specialized in the same manner, are mere black and inconspicuous insects. So among the flies: most of the omnivorous families are dull and ugly; but several of the flower-haunting tribes are adorned with brilliant colors, and live upon honey. In fact, an immense majority of the brightest insects are honey-suckers, and seem to have derived their taste for beautiful hues from the nature of the objects among which they seek their food.

There is one striking and obvious exception, however, which has doubtless already suggested itself to the minds of readers. I mean the bees. These are the most flower-loving of all insects, and yet they are comparatively plain in their coloration. We must remember, however, that the peculiar nature of the commonwealth among the social bees prevents the free action of the selective preference by which we account for the brilliancy of all other flower-haunting species. The queen, or mother bee, is a

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prisoner for life; her majesty's domestic arrangements are all made for her by the state; she does not herself seek honey among flowers, and those bees which do so have no power of transmitting their tastes to descendants, as they live and die mere household drudges. On the other hand, the solitary bees are in many cases exquisitely colored, as we might expect from their power of free choice; and one flower-haunting family of the same order, the *Chrysidæ*, are aptly compared to the humming-birds in the richness of their coloring.

One more peculiarity of great interest must also be noted. It appears that many insects have two sets of colors, seemingly for different purposes; the one set protective from the attacks of enemies, the other set attractive to their own mates. Thus several butterflies have the lower side of their wings colored like the leaves or bark on which they rest, while the upper sides are rich with crimson, orange, and gold, which gleam in the bright sunlight as they flit about among their fellows. Butterflies, of course, fold their wings with the under side outward. On the other hand, moths, which fold their wings in the opposite manner, often have their upper surfaces imitative or protective, while the lower sides are bright and beautiful. One Malayan butterfly, the *Kallima paralecta*, has wings of purple and orange above, but it exactly mimics dead foliage when its vans are folded; and, as it always rests among dry leaves, it can hardly be distinguished from them, as it is even apparently spotted with small fungi. In these and many other cases one cannot help believing that, while imitative coloring has been acquired for protective purposes, the bright hues of the concealed portion must be similarly useful to the insect as a personal decoration.

It would seem, then, that we owe half the loveliest objects in our modern world to the insect color-sense. It is the bee and the butterfly which have given us the gorgeous orchids and massive creepers of the tropics, the gentians and rhododendrons of the Alps, the camellias and heathers of our conservatories, the may and primroses of our English meadows. To the same primitive taste, exerted in a slightly different direction, are due the gilded wings of Brazilian moths, and the exquisite tints of our own ruby or sapphire colored summer insects. The beauty and the glory of the world are not for the eyes of man alone;

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they appeal equally to the bee and the butterfly, to the bird and the child. To some people it strangely seems a nobler belief that one animal only out of all the earth enjoys and appreciates this perpetual pageant of natural loveliness: to me it appears, on the contrary, a prettier and more modest creed, as well as a truer one, that in those higher and purer delights we are but participants with the vast mass of our humbler dumb fellow-creatures.

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# THE MAY BEETLE AND WHITE GRUB.

[For several years past this worm has proved a great pest in our state. It has destroyed strawberry plants, ruined large fields of grass, and preyed on the mature potato. The accompanying chapter, by Prof. J. A. Lintner, of New York, is important at this time. It is from a paper read before the New York State Agricultural Society.—SEC.]

I have chosen for my topic the May-beetle, *Lachnosterna fusca* (Frohl.), and desire to tell you what is known of it.

The larva of this species has, by common usage, received the name of "the white grub." It is not a well-chosen name, since there are several allied forms to which it might be quite as well applied; but it serves, from its general adoption, the purpose of separating it from others when we would speak of it. The perfect insect has in like manner been named the May-bug or May-beetle, and the June-bug or June-beetle. As it is a frequent visitor in our houses, where it is attracted by light, many of you have doubtless made its acquaintance in your childhood. It is a thick-bodied insect of an oval form, and of a dark brown color, and measures about eight tenths of an inch in length. Its wing-covers are shining and smooth, with the exception of two or three slightly elevated lines on each, and numerous minute impressed dots. The short antennæ terminate in three yellow leaflets or plates. The breast is covered with fine, glossy, yellowish hairs, from which it (together with the other species of the genus) owes the generic name of *Lachnosterna*, signifying woolly-breasted. The legs are tawny yellow, with black upon the joints.



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### THE WHITE GRUB.

The larva may be characterized as a large, white, soft grub, with some scattered fine hairs, a flattened, brownish or light mahogany-colored head, with six distinct, rather long, legs on the front part of the body (the first three rings), and the hinder portion of the body considerably the thickest. When thrown from the ground, it usually assumes a curved form, its head and terminal end nearly meeting. When full grown it is almost the size of a man's little finger.

There are several other "white grubs" similar to this in general appearance; but as they have habits in common to a great extent, it is not necessary, except where observations are desired for scientific uses, that they should be readily separable. From a very similar species, however, which occurs in manure, it is important that it may be distinguished, lest proper manuring should be withheld through fear that the May-bug would be conveyed with it. The May-bug grub does not occur in manure, as its food consists of living vegetable matter. The grub, which is frequently found abundantly in dunghills and may be met with under the droppings of cows in fields, is exclusively a dung feeder. It is known in some localities as the "muck-worm." Its scientific designation is *Ligyrus relictus* Say. The following features by which the two may be separated have been pointed out by Mr. Walsh. In the latter species, there may be seen on its back, through its semi-transparent skin, along the entire length of the body, a lead-colored line denoting its intestinal canal, filled with the black dung upon which it has fed. In the true white grub, the *L. fusca* larvæ, it is only near the terminal end of the body that it shows a lead-colored appearance, because it is only at this portion of the canal that the roots upon which it feeds have become digested and converted into a dark-colored excrement.

### THE EGG.

"The eggs are white, translucent, spherical, with an average diameter of .09 inch. They are deposited between the roots of grass, and are inclosed in a ball of earth before deposition, as the cavity is sufficiently large for the egg to roll about in."

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It would appear that the above is given from the personal observation of Prof. Riley, or upon reliable information communicated to him. If this be so, then the following statement cannot be accepted: "Two years ago I repeatedly saw in a garden the female depositing eggs while flying, just at dusk, an inch or so above the ground. These eggs were polished white, as large as pigeon-shot, and dropped singly. This is in contradiction to the 'authorities,' for it is stated that the female digs again into the ground and deposits about thirty eggs in one hole."

Beyond the above, I have no knowledge of any publication of observations upon the egg-laying of this species, the construction of the ball of earth in which the eggs are said to be first inclosed, or the manner of its burial. How the ball-making and its burial to a considerable depth in sod can be accomplished by the aid of feet so seemingly unfitted for such operations is incomprehensible to me.

### INJURIOUS CHARACTER OF THE INSECT.

The May-beetle may with propriety be named among our most injurious pests. It has attained the unenviable notoriety of being pronounced "one of the very worst and most insidious of the farmer's foes." If a list of our insect enemies were arranged in the order of relative importance, this species would, I think, find place among the first twenty. It is a native species, and very early notices appear of its serious injuries. It was first described nearly one hundred years ago—in 1792. Unfortunately its depredations are evidently upon the increase, particularly within our own state, as appears from the following extract, and from the many inquiries received by me of late for approved and effectual means for the arrest of its ravages.

From Washington county, N. Y., in 1881, we have this statement: "The widespread havoc which this insect has caused this year, and the fact that its ravages are increasing with alarming rapidity, is my excuse for referring to the subject. The damages in this county amount to, probably, thousands of dollars annually, and are increasing."

The extent that these depredations have already attained is a

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sufficient warrant for this present study of them, and for their presentation to your society at this time.

In their consideration, those committed in the early stage of the insect, that of the grub, will first be referred to.

### INJURIES FROM THE GRUB.

Dr. Harris writes,—"They subsist on the tender roots of various plants, committing ravages among these vegetable substances, on some occasions of the most deplorable kind, so as totally to disappoint the well-founded hopes of the husbandman."

*To Grass.*—Dr. Fitch thus notices it: "These grubs feed upon the roots of grass and other plants, which they cut off a short distance beneath the surface; and when they are numerous they advance under ground like an army, severing the turf as smoothly as though it were cut with a spade, so that it can be raised up in large sheets, and folded over or rolled together like a carpet. Often from a dozen to twenty grubs will be exposed in every square foot when the turf is thus raised. Large patches of this kind will occur in the middle of a meadow or pasture, every blade of the grass being brown and dead."

In some pasture lands near London, Ontario, throughout entire fields "the roots of the grass had been so eaten that the the turf could readily be lifted by the hand by the yard, and underneath were thousands of the grubs feeding on the remaining fragments of the roots. In one instance a field had been so completely destroyed that the farmer had set fire to the withered grass with the hope of scorching the enemy to death."

*To Corn.*—The accounts given of its destructiveness to corn are numerous. Not only does it cut off the young corn when a few inches high, but it will also destroy full-grown corn over entire fields. On Prairie Ronde, in Michigan, it appeared in such numbers as nearly to destroy many fields of corn. Upon examination of a few corn-stalks left standing in a field, the roots were found eaten off to within a few inches of the stalk, and often from three to five large grubs in a hill. Most of the corn was killed early in the season, and the few stalks left were dying a lingering death without producing any grain.

A gentleman from Nine Mile Prairie, Missouri, writes,—

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"They are destroying whole fields of corn. I have seen fields where they have destroyed the corn in patches for rods around, leaving the ground as bare as the travelled road. They seem to destroy the tap-root first, and afterward prey on the laterals."

From Washington county, N. Y., we have this statement and estimate of injuries to corn from the grub in the year 1881: "A large area of corn, in the aggregate, has been badly injured or entirely destroyed. On my own farm they caused the loss of one hundred bushels of corn alone. Much of it would pull up by the roots when struck by the knife, frequently exposing to view from five to fifteen grubs."

Mr. Glover records their extraordinary abundance in Grayson county, Virginia, in 1874, where as many as one hundred and ten were counted in a single hill. They were also during the same year quite destructive to corn crops in Huntington county, Indiana, and in Montgomery county, Missouri.

*To Strawberries.*—It has long been known as especially addicted to feeding upon the roots of the strawberry. Prof. Forbes, in his excellent address on Insects Affecting the Strawberry, read before the Mississippi Valley Horticultural Society at New Orleans, on February 22, 1883, represents it as "perhaps the most unsatisfactory insect with which the strawberry-grower has to deal, offering the fewest opportunities for effective attack. The roots of the plant are often destroyed by it to a degree to impair seriously the value of the plantation." Mr. B. D. Walsh has written of it, that it "is particularly destructive to strawberry beds, and is probably one of the chief reasons why this plant will not last more than a few years on the same spot of ground in this country." Dr. Packard records its ravages at Salem, Mass., where many plants were killed by its eating the main roots, and thus passing from one plant to another.

*To Potatoes.*—In Washington county, N. Y., during the year 1881, the grub is charged with having devoured whole fields of potatoes.

### INJURIES OF THE BEETLE.

Many of our insect pests are injurious only in their larval stage, except through the evil that they originate in the deposit of their eggs. Of this class are all of the extensive order of

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Lepidoptera, embracing the butterflies and moths, which in their winged stage are unprovided with jaws for biting. Their slender and flexible tubular proboscis, fitted only for imbibing liquids, cannot be used for any serious harm, in this particular unlike the rigid, stouter proboscis of the Hemiptera or bugs, which is capable of inflicting serious and varied injuries. The powerful jaws with which many of the Coleoptera or beetles are armed are often fitted for and employed as formidable instruments of offence. The May-beetle, while from the character of its food and a life-period of short duration it is less injurious than its insatiate and long-lived grub, is still chargeable, as a leaf-eater, with extensive depredations at times upon many of our fruit-, forest-, and shade-trees. Dr. Fitch has written of them as "gathering by night upon the trees and eating the leaves, sometimes in such numbers as wholly to strip the foliage from the choice varieties." Prof. Riley states, "I have known the Lombardy poplar to die in consequence of the utter denudation they caused, while groves of both pin and post oaks * * * were thoroughly and suddenly denuded by them."

Of the fruit-trees, the cherry and plum appear to be preferred. It was thought by Mr. Walsh that their swarming upon these trees, as they occasionally do, was not usual, except in the Eastern states, as he had not known it to occur in the valley of the Mississippi. But that they are at times quite as abundant in that region appears from the record that in Cameron, Mo., "they swarmed during the last of May, 1866, making a noise on the trees like the coming up of a storm of wind and rain." Among other trees, the beetle is recorded as feeding upon the oak, the maple, and the beech.

### LIFE-HISTORY.

When I say that the life-history of this insect is not known, I offer the best reason for our inability to give effectual means for preventing the heavy annual losses that it inflicts upon us. The brief outlines of a history that are to be found in our entomological reports appear to have no better foundation than a presumed agreement with that of the European cockchafer, *Melolontha vulgaris*,—a very poor basis, it may be remarked,—

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for, long as that notorious pest has been known and studied, the knowledge of its transformations is far from complete. Dr. Harris gives no details, but contents himself with the very broad statement that "the habits and transformations of the common cockchafer of Europe * * * will serve to exemplify those of the other insects of this family." Even so accurate an observer as Dr. Fitch, thoughtlessly and unwisely, we think, committed himself to the following statement: "Every thing known respecting the history of our May-beetle and its transformations concurs to show that it is exactly analogous to the cockchafer or May-bug of Europe." In truth, the European cockchafer, of whose excessive abundance and ravages at times we have had such graphic accounts, is not closely allied to our May-bug. It belongs to another genus, *Melolontha*, which is entirely unrepresented in this country.

Prof. Riley presents the following history, unaccompanied with the authority or observations supporting it: "Soon after pairing, the female beetle creeps into the earth, especially wherever the soil is loose and rough, and after depositing her eggs to the number of forty or fifty, dies. These hatch in the course of a month; and the grubs, growing slowly, do not attain full size until the early spring of the third year, when they construct an ovoid chamber, lined with a gelatinous fluid, change into pupa, and soon after into beetles. These last are at first white, and all the parts soft as in the pupa, and they frequently remain in the earth for weeks at a time until thoroughly hardened, and then, on some favorable night in May, they rise in swarms and fill the air. It is very probable that under favorable conditions some of the grubs become pupæ, and even beetles, the fall subsequent to their second spring; but growing torpid on the approach of winter, remain in this state in the earth, and do not quit it any sooner than those transformed in the spring. On this hypothesis, their being occasionally turned up in the fresh beetle state at fall ploughing becomes intelligible."

In all thus far written of the transformations of this insect, the element of uncertainty largely prevails. It does not appear that the larval life-duration has in one instance been ascertained; and many such determinations would be required in

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order to establish a rule of uniformity or the range of variation. Observations sufficiently reliable to contribute toward building up a life-history are almost wholly wanting. The following are of some value:

In Clinton county, Mo., the beetles swarmed late in May of 1866, from which eggs were doubtless deposited in June (the female is said to live for about a week). The grubs from these eggs were small and not very injurious in 1867. They were "full-grown, fine fat fellows" in the autumn of 1868. From the above we educe: If the larvæ then were as reported, full-grown, the beetles from them would appear in May of 1869, three years from their preceding appearance. The grubs may have either transformed into pupa in the autumn of 1868 or spring of 1869,—in the third year of their life. Their larval period would then have been either two and one third or two and three fourths years.

Dr. Packard records his having found the pupæ "in little rude cells or chambers about six inches under the mould * * * in Maine, late in May."

I will here quote from its obscure resting-place, where it seems to have been overlooked, a somewhat circumstantial history of the transformations of this insect, which, from the absence of technicalities and its general character, would seem to be the personal observations of the writer, and, therefore, of considerable value. It is from the *Patent Office Report* for the year 1852, Part II, *Agriculture* (p. 219), and is a portion of a report upon the crops of Ulster county, N. Y., made by David L. Bernard, of Clintondale.

*Corn.*—This crop is extensively cultivated in this county, and is considered the most remunerative at present. It seldom fails with us to produce a fair yield, except in seasons when the *larvæ* of a beetle are present with us. When these *grubs* prevail to a considerable extent, neither good husbandry nor high manuring can secure us a crop; and perhaps no other county has for the past twenty years suffered more loss from this than Ulster. This formidable enemy to agriculture seems gradually to be leaving us, in all probability to appear in some other place, and there to renew the same destructive process practised on us. In order to give this *beetle* a slight introduction to whom it may concern, I will give a brief description of its general appearance and habits. The bug or beetle is about three fourths of an inch in length, of a dark brown color, and

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may be seen in large numbers flying through the air in the early part of the evening, about the last of April or first of May. They deposit their eggs generally in the month of June, on grass land, on soil that is light or loamy. The larva is hatched from the egg during the month of August, and feeds upon the roots of vegetables until the ground becomes frozen; it then descends below the frost, and there remains in a state of torpidity until the following spring. As the frost leaves the ground it ascends to the surface (exhibiting no increase of growth during the winter), and again resumes its former mode of living, carefully secluded from the rays of the sun, feeding on the roots of almost all kinds of grasses and vegetables. Its movements are slow and sluggish; its color nearly white, with the exception of the head, which is red. It has six legs, three on each side. It is at this age about one inch in length. It continues its destruction of all green vegetable matter with which it may come in contact until the ground becomes frozen again. This is its most destructive season through its progress of change. As the ground becomes frozen, it again descends below the frost (in some instances six feet below the surface), as before remains torpid until the next spring, when it again appears at the surface, being now about one and one quarter inch in length. It continues to feed as usual upon vegetable substances until about the middle of June, when it ceases to feed, descends deeper into the earth, and becomes torpid until about the middle of August, when a complete change occurs. It opens lengthwise from the head, back near one half its length, and forthwith appears in the chrysalis state, in which it remains nearly inactive until about the last of September, when it changes into a perfect state or beetle, and still remains in a nearly torpid state until the following spring, when, about the last of April, it ascends to the surface, and immediately commences to reproduce its species.

It has thus far baffled the ingenuity of man to prevent its ravages, while fields of timothy have, within a few weeks, been entirely destroyed by this grub, and thousands of acres of corn have been totally lost in this county by its ravages.

According to the above statement, the larval stage proper would be of the duration of *two years*.

### DISTRIBUTION.

This insect is one of very extensive distribution, being found in all parts of the United States, and extends northward into British America, where it occurred in Kirby's collections in north latitude 54°—the latitude of Labrador and Hudson's Bay.

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ITS ENEMIES.

An excellent reason for the amount of injury which this insect imposes upon us is found in the few insect or other enemies that prey upon it, protected as it is by its subterranean life in its first three stages, and its unusually brief final stage. Only one insect parasite is known to attack it. It has, however, several vertebrate enemies which render good service in restraining its unlimited increase. These will first be noticed.

*The Skunk.*—There is abundant testimony of the service rendered by skunks in the destruction of the grubs, and to the expertness which they manifest in the discovery of their presence, and in making them their prey. It has been thought that one reason among others for the multiplication of the grub in localities in the Western states and elsewhere is to be found in the wholesale slaughter of the skunk, since their skins have obtained commercial value as a fur. In the *Country Gentleman* of December 1, 1881 (p. 778, col. 2), we have the following observations: "A few years ago, before skunk skins became so valuable as furs, I had a pair of half-tamed skunks which I used to let out every evening to dig for grubs; and it was wonderfully interesting to see their infallible scent or instinct in discovering the location, and then their astonishing celerity in digging out and gobbling the grubs. But most astonishing of all was the quantity of grubs those two little beasts would devour every evening. I have often watched them; and, incredible as it may seem, I could not say that they ate less than half a bushel daily!" To the above statement the suggestion is added, that a very valuable ally might be obtained in our war against the white grub by removing the odoriferous glands from the skunk, and domesticating him for employment as a grub-killer. A correspondent from Washington county, N. Y., gives this testimony: "Before skunks began to be hunted, we had no trouble with the white grub, and I think they kept them down. I often found my corn-hills rooted into, evidently by skunks in search of grubs. Those dug into early in the season made a fair crop, while those untouched until later were destroyed. I have also seen the same signs in meadows and pastures."

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Not only are the grubs so eagerly sought for and devoured by this animal, but it is also, according to Dr. Fitch, a natural destroyer of the beetle, its food consisting almost entirely of this insect during the short period of its existence. This is in accordance with the statement of Dr. Harris, to the effect that the beetles are devoured by the skunk, whose beneficial foraging is detected in our gardens by its abundant excrement filled with the wing-cases of these insects.

*Raccoon.*—Dr. Thomas names the raccoon as one of the carniverous animals that prey upon this insect, but does not state to what extent it destroys it.

*Mole.*—Prof. Claypole, a careful observer of the habits of insects and other animals, permits us to claim the mole as an auxiliary in our warfare against the white grub. The following is what he saw, writing from Yellow Springs, Ohio: "In digging potatoes this year, I observed the runs of a mole in all directions through the ground. It was a piece of old sod, and very much infested with white worms, the larva of the cockchafer, *Lachnosterna fusca*. Many of the potatoes had been partly eaten by these worms, but I observed that wherever a mole-run traversed a hill of potatoes no white worm could be found, even though the half-eaten potatoes were proof of his former presence. The inference is fair that the mole had found him first and eaten him, and very likely the mole's object in so thickly tunnelling this piece of ground was to find these grubs."

*Domestic Fowls.*—If these be watched as they follow the plow in our gardens and fields in search of such insects as may be brought to the surface, it will be seen that they show a special fondness for the white grub. Their presence during the operation of ploughing should, therefore, always be encouraged.

*The Crow.*—The common crow feeds upon both the beetle and the grub. It is believed by many that its frequent occurrence in corn-fields is the result of its fondness for the grub which is preying upon the young corn, rather than upon the corn itself. The studies that have been so ably conducted during the last few years upon the food of birds should have settled ere this the question, beyond all doubt, whether the crow is to be driven from, or invited to, our corn-fields.

*Other birds.*—The beetles have been found in the stomach of

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the king-bird, *Tyrannus Carolinensis*, shot in the month of May. The robin, blackbird, and jay are also said to feed upon them.

*Insects.*—The grub has also enemies among its own class, which prey upon it. Several of the predaceous beetles are said to devour it—species of the rapacious *Carabidæ*, probably *Calosoma calidum* and others, but their names have not been recorded.

*A Parasite.*—While many insect attacks are restrained through the beneficent aid of other insects, which in our gratitude we are apt to regard as specially commissioned to perform this duty for our protection, thus far we know of but a single parasite which is waging warfare upon the white grub. This insect was described and figured by Prof. Riley, in his *Sixth Report on the Insects of Missouri*, as the white grub parasite, *Tiphia inornata*. It is one of the digger-wasps; and the ease with which these creatures are able to burrow in the ground enables this one to discover the grub in its concealed retreats, and by depositing an egg upon the body, to provide the food needed for its progeny, and to insure the death of the attacked grub. The parasitic larva having matured, it incloses itself for its changes in "an egg-shaped cocoon of a pale golden-brown or buff color, and with a soft exterior surface in touch as well as color. * * * Upon cutting this cocoon open, it will be found to consist of about a dozen delicate layers, the outer ones soft and loosely spun, the inner ones more and more compact, and paler in color." Their presence in the ground (from the above description they may be easily recognized) serves to show the parasitic attack. They have in some instances been met with in such numbers in association with a formidable grub attack as to arrest attention, and to induce inquiry into their character.

*The White Grub Fungus.*—For another destroyer of the white grub, and the most interesting of all that we have referred to, we have to turn to the vegetable kingdom, to that low class of plants known as *fungi*. From its being so often found upon this species, it has been popularly named *the white grub fungus*. Scientifically, it is known as *Cordyceps Ravenelii* Berkeley. It was described in 1857, but its economic importance in its association with the white grub was not known until brought to notice by Walsh, in 1867, upon the reception of specimens from

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a large number of the grub killed by this growth, which had been ploughed up in a field in Iowa. Its character was not understood at the time, Mr. Walsh suggesting that, but for the numbers found, the grub might have swallowed a seed which subsequently sprouted and grew. Later, its fungoid character was disclosed. Its general appearance is that of a pair of elongate horns, green at first, but subsequently changing to brown, issuing from the lower side of the larva, between the head and the first joint. In length they vary from less than that of the larva to three or four times as long.

This interesting parasite occurs at times in considerable abundance, more particularly in the West and South.

It has been suggested that this fungus attack might be extended through propagation and distribution of the spores of the fungus, but I am not aware that the experiment has been made.

### PREVENTIVES AND REMEDIES.

Passing now to the more practical portion of this paper, we will consider what may be done to control the ravages of the insect of which we have been speaking; and first, the preventive means that promise protection.

*Ashes.*—It is stated that for strawberries, which are so liable to attack, an efficient protection is found in placing a quantity of ashes, either leached or unleached, upon the ground before setting the plants. This is upon the authority of Dr. Barnes, of Owasso, Mich.

*Tobacco.*—A gentleman from Westwood, N. J., states that by digging (burying) tobacco stems into strawberry beds the injury of the grub may be prevented.

*Rolling, etc.*—Compacting the surface of the ground by treading it with sheep or cattle, or by the use of heavy rollers, might give protection from the deposit of eggs by the inability of the beetle (if this be its habit) of excavating the earth for the purpose, and might also serve to prevent the easy passage of the grubs, if in the soil, from one root to another. Still this method, which has been urged for use against many insects by English writers, seems so opposed to the condition of looseness and pulverization of the soil which is well known largely to promote vegetable growth, that we incline to the belief that

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whatever protection it might yield from insect injury would be counterbalanced by a stunted crop.

*Gas-lime.*—Although not tested by experiment, I have great faith in the efficacy of gas-lime as a protection from the deposit of the eggs of the beetle, or, if the protection be but partial, then for the destruction of such eggs as may have been deposited. Upon ground to be seeded or planted, the lime, fresh from the works, might be distributed and worked into the soil; but where the crop to be protected is already upon the ground, the lime should first undergo such atmospheric exposure as would permit of its use as a top-dressing without harm to the vegetation. It should be applied during the month of May or June, or as soon as the beetles are seen upon the wing.

We may pass now to remedial measures, and first, to those referring to the destruction of the beetle.

*Tree-shaking.*—The May-beetle has a habit in common with many other species of becoming gregarious in times of its great abundance, when it assembles in multitudes for the night upon fruit-trees. This habit permits of its destruction in large numbers, and the reduction of the following brood to the extent that its eggs have not at this time been deposited, by shaking them from the trees upon sheets spread underneath. Dr. Harris records that in this way two pailfuls of beetles were collected on the first evening of the experiment, the number decreasing upon following evenings until the fifth, when only two beetles were to be found. He adds,—"The best time, however, for shaking the trees * * * is in the morning, when the insects do not attempt to fly. They are most easily collected in a cloth spread under the trees to receive them when they fall, after which they should be thrown into boiling water to kill them, and may then be given as food to swine."

Dr. Fitch, in referring to this remedy, gives the time in which the trees may be shaken with the best results as between midnight and daylight, as would appear from the observations of Mr. Milo Ingalsbe, of South Hartford, Washington county, N. Y. "He had seventy plum-trees and a number of cherry-trees of the choicest varieties, which never gave fairer promise of an abundant yield than at that time. But a swarm of these May-beetles suddenly gathered upon the trees, many of them being

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then splendidly in bloom, and in two nights, the 15th and 16th of May, wholly stripped them of their foliage, so that many of them were as naked as in winter. With their humming notes these beetles were flying about the trees every evening until about ten o'clock, when they would settle in clusters of eight, ten, twenty, or more, and would thus remain until daylight, when they would tumble down from the trees, flying but little, however, and hiding themselves wherever convenient to stay through the day.

*Attracting to light.*—The beetles in their evening flights are readily attracted to light, as is shown in the frequency with which they fly in at the open windows of our dwellings, public halls, churches, etc., in warm evenings, and the numbers that may be seen circling about the electric lights of our streets, or lying upon the pavements beneath, to which they have fallen. This well known propensity of the beetle may be utilized to lure them to their destruction. If a lantern be placed above a vessel of water upon which two or three tablespoonfuls of kerosene has been poured, many of the beetles, drawn to the light and striking against it, will be thrown into the water and killed. Many other noxious insects may at the same time be killed by this method.

In our efforts to destroy the *larva*, we are met with several difficulties, of which these may be given:

1. Applications to the ground of sufficient strength invariably to kill the grubs, of which several might be mentioned, would also be destructive to a growing crop.

2. The strongest applications that may with safety be applied would be so impaired in strength in entering and penetrating the ground as to become inefficient at a moderate depth.

3. The grub has the ability of withdrawing itself from the obnoxious application by burying itself deeper in the ground.

In consideration of the above and like difficulties effort should be directed toward the discovery of some substance which will act upon the grub through other means than its exceeding strength. Should it be of such a character as simply to be repulsive to its taste, there is reason to believe that, rather than to feed upon roots that are saturated with it, it would die of starvation. In this manner, perhaps, may be found the reputed effi-

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cacy of the application next to be noticed. Experiments in this direction are very desirable.

*Salt* —The application of salt has been pronounced an effectual remedy, while it has also been said to be of no avail whatever. The remedy would be so simple, and withal so inexpensive, that the claim made for it should be tested by careful experiments. It is possible that the reputed success may have resulted from its employment in the year of the greatest ravages—that preceding the transformation to the beetle, for during this year (next after the application), from the moderate growth of the young grub, there would necessarily be a comparative immunity from injury. On the other hand, the ascribed failure may have followed a too economical use of the cheap material, perhaps through fear of injury to the crop. A gentleman who strongly recommends this remedy, presumably from having thoroughly tested its value, deems it essential that the salt should be used in large quantity. He writes,—"The great error with those who have used it with unsatisfactory results has been its scanty application. I can assure the reader that grass or potatoes will grow luxuriantly under an application of *one ton and a half per acre*, which quantity would be sure to result in the complete extermination, not only of the grub, but every other kind of worm, and prevent the scab and other excrescences which sometimes appear on potatoes, as well as preventing rot. A less quantity, say half [three fourths of a ton], or even two or three barrels to the acre, though of course not as effectual, will accomplish much."

If the above testimony to the value of salt as a grub-killer shall be sustained by further experiment, I would strongly urge, in view of the periodic character of these attacks in localities, that the salt be applied *in the year of the abundant appearance* of the beetle, and preferably during the month of August or September, although no injury from the grub may be apparent. At this time the young grubs which are produced from the eggs deposited in June are within reach of the application, and may be killed far more readily than when they have attained additional powers of resistance in another year's growth.

*Rooting out by Swine.*—The value of swine in freeing infested grass lands from the grub has often been urged, and, we think,

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is not overestimated. I believe that this remedy will prove successful, if good rooters be employed, when other methods fail. Dr. Fitch has written as follows of it:

"I would recommend the placing of a temporary fence around that portion of the meadow or pasture which is so thronged with these grubs, thus for a while converting the patch into a hog pasture. The propensity of these animals for rooting and tearing up the turf, we are all aware, is for the very purpose of coming at and feeding upon the grubs and worms that are lurking therein; and who knows but that this rooting propensity, which has all along been complained of as being the most vicious and troublesome habit which belongs to swine, may after all turn out to be the most valuable and necessary to us of any of the habits with which they are endowed. * * * I cannot but think these animals, confined upon a spot so overstocked with grubs, would in a short time ferret out and devour every one of them, leaving the soil cleansed, mellowed, manured, and well prepared for being immediately laid down to grass again, or for receiving any other rotation of crops for which the proprietor may deem the spot best adapted."

Mr. Walsh, formerly State Entomologist of Illinois, had equally strong faith in the value of this method of overcoming the white grub attack. After discoursing upon the great increase in the insect as observed in a few preceding years, its growing injury to young nurseries and its violent irruption upon corn, which had formerly been exempt from it, he adds,—"I suspect that the above phenomena are to be wholly or partially attributed to the introduction of improved breeds of hogs in the place of the old, slab-sided, long-nosed prairie-rooters, and to the passage of laws compelling people to keep their hogs under fence instead of allowing them to run at large. * * * Within the last few years such laws have been very generally passed in the Western states. * * * Hence, I am inclined to infer that the presence of the white grub is often to be attributed to the absence of the hog."

Without occupying your time in a review and discussion of various other methods that have been proposed for destroying



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the grub, I will refer to but one other, which I regard as an effectual one wherever it may be resorted to:

*Starvation.*—As soon as the attack is discovered, upon the removal of the crop, collect and burn, so far as practicable, all the vegetable material upon which the larvæ could feed. If the ground has been cultivated for vegetables, gather all the stalks, stems, vines, etc., together with the roots, in piles, and burn them. If the land be in grass, after feeding as closely as possible, plough thoroughly, and follow during the autumn with such additional ploughings and harrowings as shall best tend to destroy all vegetable life. At this time gas-lime, if procurable, should be applied. Repeat these operations in the following spring, and allow the land to lie fallow for the year. Compliance with these directions would not only starve out the white grub, but also whatever wire-worms, cut-worms, and other underground larvæ there might be present.

The fallowing of the land for an entire year may be found to be unnecessary. It is not improbable that it might be preferable that the thorough breaking up of the ground in the autumn and spring be followed with a crop of buckwheat. Wonderful efficacy has been claimed for this plant in freeing the ground from wire-worms—the larvæ of other beetles—and we know not why it may not be equally efficient when employed against the white grub. By all means let thorough tests of its value be made, since the trial is so simple. Hon. A. B. Dickenson, after experimenting with salt and lime for destroying wire-worms, has stated,—"I have only proved one remedy for the rascals, and that is, to break the sod and sow it to buckwheat. Plough late and as often as possible in the fall, and then sow it to pease in the spring. With the like ploughing next fall, they will not disturb any crop the next season."

In England a crop of mustard is regarded as an antidote against the wire-worm. In an address before an agricultural society there, the speaker, after detailing some successful experiments upon a small scale with mustard, stated as follows: "Thus encouraged by these results, I sowed the next year a whole field of forty-two acres, which had never repaid me for nineteen years in consequence of nearly every crop being destroyed by the wire-worm; and I am warranted in stating that

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*not a single wire-worm could be found the following year*, and the crop of wheat throughout was superior to any that I had grown for twenty-one years." Certainly this very successful experiment, confirmed as it is by many others that I find recorded, deserves to be faithfully tested with the white grub.

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# NEW POINTS IN ENSILAGE.

It has become a settled fact that ensilage from corn, clover, rye, millet, and other forage plants, is an important and economical element in the winter feed of our farm stock. To question it is not wise: to disbelieve it is to act in opposition to the most substantial evidence.

There are, however, questions regarding it which will require study and practice. It has already been settled that much less pressure is necessary than was at first supposed, and it has also been demonstrated that cheap silos are preferable to those of stone and cement. It is desirable that they exclude the air to a good degree, but the pressure accomplishes this object, and often is so great as to force the atmosphere out of all except the edges of the mass. There has been much discussion relative to the length at which the forage should be cut. The shorter, the more compact, and the better the preservation. But whole plants of corn have been packed away in the silo, and put under even a medium pressure, and come out in winter in a fine state of preservation.

It has been supposed that there must be especial haste in putting the material into the pit; but we have known parties that extended the storage over several days, and experienced no bad result. In fact, better ensilage is believed to have been produced by the slow process. From a paper on this topic, by Prof. Miles of the Massachusetts College of Agriculture, we take a record of his experience, greatly abridging his original draft.

That there are great differences in the quality of the ensilage made on different farms, or even in that made on the same farm

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in different seasons, there can be no doubt, and these differences must be attributed to variations in the conditions under which the ensilage is made, which must result in corresponding modifications of the process of fermentation. When the influence of these varying conditions, which include the peculiarities of the crop as well as the method of filling the silo, is so well understood that ensilage of a uniform and desired quality can be produced with certainty, the most important objections that are now made to it will be obviated, and it will readily take its place on the farm as a staple article of cattle-food.

My studies of ensilage have for some time past been directed to methods of preventing acidity, and securing a desirable degree of uniformity in quality; and thus far the results are, to say the least, encouraging. The experimental wooden silo at the Massachusetts experiment station was made under my direction. It was filled in two and a half days with over seventeen tons of fodder-corn, cut in one and a fourth inch lengths, and thoroughly packed as it was put in. A tight cover made of two thicknesses of planed boards and planks was put on, and loaded with barrels of earth that were estimated to give a pressure of over sixty pounds per square foot. For convenience of access to the interior of the mass, a gas-pipe, one and a fourth inch in diameter, was driven through a hole in the middle of the cover, to the depth of four feet, the upper end being carefully packed to make a tight connection with the planks of the cover, and the upper end was closed with a plug.

When the cover was put on, September 8th, the temperature was 82° Fahr., two feet below the surface. Observations were made, from time to time, of the temperature and rate of settling, as recorded in the following table:

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| DATE. | Depth of ensilage. | Temperature of ensilage four feet from the surface. | Temperature of outside air. |
|---|---|---|---|
| | Ft. In. | Degrees Fahr. | Degrees Fahr. |
| September 8th | 8 6 | 82 | ..... |
| " 9th | 7 7 | 82 | ..... |
| " 10th | 7 2¾ | 78 | ..... ..... |
| " 11th | 6 9 | 77 | ..... ..... |
| " 12th | ..... | 82 | 62 |
| " 14th | ..... | 84 | 55 |
| " 15th | 5 11½ | 84 | 68 |
| " 16th | 5 11¼ | 87 | 72 |
| " 17th | 5 10½ | 85 | 69 |
| " 18th | 5 9¾ | 82 | 59 |
| " 19th | 5 9¾ | 84 | ..... |
| " 20th | 5 9½ | 84 | 61 |
| " 21st | 5 9¼ | 84 | 62 |
| " 22d | 5 9 | 83 | 56 |
| " 24th | 5 9 | 82 | 61 |
| " 25th | 5 8½ | 80 | 58 |
| " 26th | 5 8¼ | 80 | 50 |
| " 27th | 5 7¾ | 80 | 50 |
| " 28th | 5 7½ | 80 | 60 |
| " 29th | 5 7¼ | 79 | 53 |
| " 30th | 5 7¼ | 78 | 59 |
| October 1st | 5 7⅛ | 78 | 50 |
| " 2d | 5 7⅛ | 76 | 48 |
| " 3d | 5 7 | 76 | 44 |
| " 4th | 5 6⅞ | 76 | 43 |
| " 10th | ..... | 68 | ..... |
| " 27th | ..... | 65 | ..... |
| November 7th | ..... | 64 | ..... |
| " 18th | ..... | 59 | ..... |
| December 3d | ..... | 54 | ..... |
| " 15th | 5 5½ | 49 | 22 |

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The weights as applied gave a uniform pressure; but the cover, as will be seen from the table, did not settle at a uniform rate. There was a fall of 5° in temperature during the first three days; then followed a gradual but not uniform rise, until the maximum of 87° was reached at the end of the first week. It will likewise be noticed that a variation of but 5° from the initial temperature occurred during the first three weeks after the cover was put on and weighted, and that the fall in the temperature was not uniform.

Experiments were repeatedly made with samples of ensilage, taken through the tube, from the interior of the silo. The samples obtained on the 9th of September swarmed with bacteria, which were remarkably active and rapidly increasing by self-division. After the first few days the indications of rapid reproduction were not so marked, but the activity of the bacteria was not sensibly diminished until the temperature had fallen below 60°, more than two months after the silo was filled. The variations in temperature and in the rate of settling were undoubtedly connected with the vital activity of the bacteria, but the precise relation of these variations could not be traced.

The real significance of these minute organisms cannot be fully appreciated without a review, including a brief history, of the known facts of the process of

## Fermentation.

The alchemists were acquainted with ferments and fermentation as early as the thirteenth century, but we need not stop to notice their crude theories in regard to the process. In 1659, Willis, an English physician, presented a theory of fermentation, which was revived by Stahl, the originator of the phlogiston theory, in 1697. According to the theory of these philosophers, ferments had a peculiar motion of their particles which they communicated to the particles of fermentable substances, and thus produced fermentation. The discovery of carbonic acid by Black (1752), of oxygen by Priestley (1774), and of the composition of the atmosphere and water by Cavendish (1781), laid the foundation for the experiments of Lavoisier, who attempted a quantitative determination of the changes taking place in the transformation of sugar into alcohol. Gay-Lussac (1815), re-

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vised the figures obtained by Lavoisier, by less perfect methods, and made a close approximation to a correct formula. In 1828 Dumas and Boullay pointed out and corrected errors in the formulæ of Gay-Lussac, and in this amended form they were, for many years, accepted as an accurate statement of the phenomena of alcoholic fermentation. Afterward, however, the discovery was made that glycerine and succinic acid are constant products of the process, and the formulæ had to be again corrected. These formulæ, even in their amended form, did not take into the account the yeast which had been recognized as an essential element in the process, and theories were formed to account for its action. Berzelius attributed the influence of yeast to a "catalytic" action—mere contact with the ferment being sufficient to excite fermentation in a fermentable substance without any other direct relation. In 1840 Liebig presented a theory of fermentation which was generally adopted by chemists. He recognized fermentation and putrefaction as essentially similar processes. Albuminoid substances, from the complex arrangement of their molecules, were assumed to be in a state of unstable equilibrium tending to decomposition, and their putrefactive transformations, which were communicated to fermentable substances, were the cause of fermentation. He claimed that "yeast produces fermentation in consequence of the progressive decomposition which it suffers from the action of air and water." Fermentation and putrefaction were claimed to be processes of combustion or oxidation. This theory was more fully elaborated, in 1848, by assigning to the decomposing albuminoid ferments a peculiar molecular motion which communicated to fermentable substances a similar vibration of their particles, and a consequent decomposition. This was, in fact, but a revival of the theory of Willis and Stahl, more than two hundred years before. Notwithstanding its general acceptance by chemists, Liebig's theory failed to recognize one of the essential factors of fermentation; and we must now turn our attention to a brief outline of some of the discoveries which disproved it, and furnished on the other hand a complete and satisfactory explanation of the process.

Leeuwenhoek, in 1680, made the discovery that yeast was composed of minute granules, but, with the imperfect lenses of that time, he failed to determine their real character. Fabroni,

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in 1787, described the yeast-granules as a vegeto-animal substance; and Astier, as early as 1813, claimed that this ferment was endowed with life, and derived its nourishment from the fermenting materials, thus causing fermentation. About 1838 Cagniard-Latour and Schwann, by independent observations, rediscovered the yeast-granules of Leeuwenhoek, and, by means of the better microscopes at their command, succeeding in proving that they were vegetable cells which were reproduced by budding. Schwann, by a series of ingenious experiments, proved that the germs of the living ferments were conveyed to fermentable substances by the air, and that they were the cause of fermentation, while the free admission of oxygen, under conditions that excluded the germs, was without effect. The experiments of Schwann were, in themselves, sufficient to establish the truth of the physiological theory of fermentation, but they were entirely ignored by Liebig and the advocates of his chemical theory. A complete demonstration of the true theory of fermentation was fially made by Pasteur (1857–'79 ) in a series of experiments which, from the skill displayed in their conception, and the remarkable accuracy secured in conducting them in accordance with strictly inductive methods, may safely be classed among the most brilliant records in the history of science. He repeated the experiments of his predecessors, invented new methods of investigation by which he was enabled to eliminate all possible sources of error, and answered his opponents by an accumulation of experimental evidence that could not be controverted. He proved that sugar was acted upon by a variety of ferments, each giving its own peculiar product, and that the different kinds of fermentation, properly so called, as the alcoholic, the lactic, the acetic, the viscous, the butyric, and putrefactive, were each the result of the vital activity of distinct and and specific organisms.

Ferments are now generally divided into two classes: 1. The so-called soluble or chemical ferments, as acids and diastase, which "invert" cane-sugar and transform it into dextrose, or change starch into dextrine. These soluble ferments, according to Dumas, "always sacrifice themselves in the exercise of their activity," but they do not produce fermentation in the strict sense of the term. 2. The true ferments, which, through the

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investigations of Pasteur, are now known to be living organisms, produce fermentation as a function of their vital activity. Unlike the soluble ferments, these living organisms increase at the expense of the substances fermented. The true fermentations are therefore purely physiological processes, which are defined by Pasteur as "the direct consequence of the processes of nutrition, assimilation, and life, when they are carried on without the agency of free oxygen," or "as a result of life without air."

The organized ferments, which belong to the class of fungi, may be divided into two groups, the saccharomycetes, or budding fungi—the active agents of alcoholic fermentation, of which yeast may be taken as the type—and the schizomycetes, or fission fungi, which include the lactic, the butyric, and similar ferments, and the organisms that produce putrefaction: most of them are of the form known as bacteria, and they multiply rapidly by subdivision. It is probable that all the members of both groups propagate by means of spores, as well as by their special processes of budding and fission, but there are many species in which reproduction by spores has not been observed. The living organisms (bacteria) found in samples of fresh ensilage, belong to the group of schizomycetes. Thus far no members of the group of saccharomycetes (yeast or alcoholic ferments) have been observed, by me, in samples from the interior of the silo that had not been exposed to the air. When a large surface of ensilage is exposed to the air, after the silo is opened, a variety of ferments may make their appearance, and with them several species of molds, but they are evidently produced from germs derived from the air.

The mold-fungi are not included in the class of ferments, as Pasteur has proved that they act as ferments under exceptional conditions only, and even then they do not produce active fermentation. The alcoholic ferments have been studied more thoroughly than the others, from their importance in the manufacture of beer, wine, etc., but many of the facts developed in their investigation are undoubtedly applicable to other ferments.

From Pasteur's experiments with fruits in an atmosphere of carbonic acid, it appears that any vegetable cells which are capable of extracting their needed supply of oxygen from organic combinations may, by this manifestation of their vital activity,

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act as ferments; and the true ferments are distinguished from these, not by a difference in their specific action, but from the fact that they are capable of carrying on the functions of nutrition and assimilation with much greater activity without a supply of atmospheric oxygen. Pasteur has likewise proved that the alcoholic ferments develop rapidly in the presence of air, but that their function as ferments is impaired by this ready supply of oxygen. In the absence of air, on the other hand, as in an atmosphere of carbonic acid, they take their supply of oxygen from organic substances, as sugar, and their function as ferments is increased. When the life of the bacteria, or other organized ferments, is destroyed, the processes of fermentation and putrefaction cease, and this takes place at a temperature of from 122° to 140°, according to observations made in the course of the controversy in regard to spontaneous generation. After the organized ferments are killed, fermentation or putrefaction cannot take place until the living ferments are again introduced. The canned articles of food which are now so common in the markets are an illustration of the application of this principle. In their preparation heat is applied, which kills the bacteria—the active agents of fermentation—and the cans are then sealed to prevent the introduction of a fresh supply of germs from the atmosphere. The popular notion that canned articles of food are preserved by excluding the atmospheric oxygen, which has been derived from the application of Liebig's chemical theory of fermentation, is without foundation. The experiments of Schwann, Pasteur, and Tyndall conclusively prove that articles which are peculiarly liable to undergo putrefactive changes, as urine, and an endless variety of vegetable and animal infusions, can be kept without change for months and years when abundantly supplied with free oxygen, if proper precautions are taken to exclude the living organisms that are the real cause of fermentation. These experiments have likewise proved that the germs of the bacteria of fermentation and putrefaction are widely distributed in the air, and the supposed cases of spontaneous fermentation, or putrefaction, are readily explained by the "seeding" of the fermenting substances with germs derived from the atmosphere.

As fermentation is strictly a physiological process, the fer-

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mented product may be looked upon as the residuum of what is required in the nutritive processes of the bacteria of fermentation.

The variations in the quality of ensilage, to which attention has already been directed, are readily explained by differences in the condition of the crops, as to maturity and development, and the manner in which it is packed in the silo, all of which must have an influence on the performance of the nutritive functions of the bacteria, and corresponding variations will consequently be presented in the residual or fermented product. As in other cases involving the activity of living organisms, the molecular changes taking place under such different conditions cannot be expressed in any definite chemical formula.

In advocating these views, Pasteur says,—"Originally, when fermentations were put among the class of decompositions by contact-action, it seemed probable, and in fact was believed, that every fermentation had its own well defined equation, which never varied. In the present day, on the contrary, it must be borne in mind that the equation of a fermentation varies essentially with the conditions under which that fermentation is accomplished, and that a statement of this equation is a problem no less complicated than that in the case of the nutrition of a living being. To every fermentation may be assigned an equation in a general sort of way—an equation, however, which, in numerous points of detail, is liable to the thousand variations connected with the phenomena of life. Moreover, there will be as many distinct fermentations brought about by one ferment as there are fermentable substances capable of supplying the carbon element of the food of that same ferment, in the same way that the equation of the nutrition of an animal will vary with the nature of the food which it consumes. As regards fermentation producing alcohol, which may be effected by several different ferments, there will be, in the case of a given sugar, as many general equations as there are ferments, whether they be ferment-cells properly so called, or cells of the organs of living beings functioning as ferments. In the same way the equation of nutrition varies in the case of different animals nourished on the same food, and it is from the same reason that ordinary wort produces such a variety of beers when treated with the

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numerous alcoholic ferments which we have described. These remarks are applicable to all ferments alike;—for instance, butyric ferment is capable of producing a host of distinct fermentations, in consequence of its ability to derive the carbonaceous part of its food from very different substances, from sugar, or lactic acid, or glycerine, or mannite, and many others. When we say that every fermentation has its own peculiar ferment, it must be understood that we are speaking of the fermentation considered as a whole, including all the accessory products. We do not mean to imply that the ferment in question is not capable of acting on some other fermentable substance, and giving rise to fermentation of a very different kind. Moreover, it is quite erroneous to suppose that the presence of a single one of the products of a fermentation implies the coexistence of a particular ferment. If, for example, we find alcohol among the products of a fermentation, or even alcohol and carbonic acid gas together, this does not prove that the ferment must be an alcoholic ferment, belonging to alcoholic fermentations, in the strict sense of the term, nor again does the mere presence of lactic acid necessarily imply the presence of lactic ferment. As a matter of fact, different fermentations may give rise to one or even several identical products "

From this statement of the physiological conditions that modify the products of fermentation, it must be seen that uniformity in the quality of ensilage can only be secured by preventing fermentation altogether, or confining it within the narrowest possible limits. This can only be done by killing the bacteria of fermentation in the earliest stages of their activity, which would result in the production of ensilage free from acidity, and closely resembling, in quality, the green fodder from which it is made. If the bacteria can be killed when the silo is covered and weighted, the inclosed mass of ensilage will be practically preserved under the same conditions as fruits, or vegetables, or meats are preserved when canned.

The practical question, then, presents itself as to how this can best be accomplished. An extended series of observations on the samples of ensilage from the experimental silo has already been made, to determine the temperature required to kill the bacteria which cause the acid fermentations. This will, undoubt-

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edly, vary somewhat with the kind of produce under treatment, and its condition when put into the silo. Thus far my experiments seem to indicate that a temperature of from 115° to 122°, maintained for one or two hours, will be sufficient to kill the bacteria under the conditions in which they are now placed. In this connection attention must be called to the fact that the time of exposure to a given temperature is quite as important as the temperature itself. A given temperature, continued for several days, may have a better effect than a higher one maintained but a few minutes. Again: A degree of heat that will kill the mature and active bacteria will not, in all probability, kill the germs which may produce succeeding generations of active bacteria if the given temperature is continued but a short time.

From the results recorded in the table, it is reasonable to infer that an initial temperature sufficiently high to kill the active bacteria would be continued for several weeks, and this, in all probability, would insure the destruction of any successive generations of bacteria that might be produced from the germs that had not been killed. For this purpose, silos with walls of wood may have an important advantage over those constructed of materials that are better conductors of heat.

In filling the silo, all writers on ensilage agree in giving directions which are based on Liebig's chemical theory of fermentation. The thorough packing of the ensilage as it is put in, and the rapid filling of the silo, are points that are strongly urged to prevent, so far as possible, the exposure of the fodder to the oxygen of the atmosphere, which is assumed to be the exciting cause of fermentation In the light of the physiological theory of fermentation, it will, however, be readily seen that the living ferments, which produce acidity, are buried with the fodder as it is packed in the silo; and the exclusion of the atmosphere, as Pasteur has proved, is a condition that favors fermentation, the oxygen itself not being directly concerned in the process. When the greatest care is taken in packing the ensilage, the temperature of the mass will often rise above 100° Fahr. (I have observed a temperature of 105° under such conditions); and when the time of filling is extended over several days, a considerably higher temperature may be developed.

There are good reasons for the belief that, with less packing

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of the fodder when put in the silo, the time of filling may be safely extended until the temperature rises to a point that is fatal to the bacteria; and this is the probable explanation of the reported cases in which the ensilage is said to be "sweet," or free from acidity.

The efficient cause of this preliminary heating process, or the changes in the fodder involved in its development, have not been determined by experiment, and we do not know the precise conditions under which the best results may be obtained.

In the present state of our knowledge of the subject, the most desirable method may be to fill the silo without any packing beyond that produced by the weight of the superincumbent mass, and then allow it to remain until the desired temperature is reached before putting on the cover and weights. The best method can only be determined by carefully conducted experiments, that are made with a full knowledge of the different conditions that may have an influence in modifying the results. It cannot, however, be doubted that sour ensilage can only be produced by conducting the process so that the temperature does not rise above the point that is fatal to the bacteria (probably 115° to 120°). Observations on temperature have been generally neglected when silos were filled; and we therefore lack the necessary data for determining the precise temperature required to prevent fermentation, or the most favorable conditions for producing it, from the results of practical experience.

Several cases have been reported to me in which the fodder at the time of filling the silo was supposed to be "spoiled" from the high temperature developed before it was covered and weighted; but on opening these silos, after several months, the result uniformly obtained was ensilage of the best quality, free from acidity. But a single case has, however, come to my knowledge, in which the exact temperature was recorded at the time of filling the silo, when the resulting product was *sweet* ensilage. Mr. George Fry, of England, reports the results of his experience the past season, which is of particular interest in connection with my experiments with ensilage. He filled a silo with *Trifolium incarnatum* (crimson clover), "rough grass," and "clover and rye grass," between the 7th and 30th of June, the temperature recorded at the time of covering being 132° six

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feet from the surface. The cover was weighted with twelve inches of sand. On July 11th, and again on the 17th, the cover was taken off, and the silo was filled with "meadow-grass" to make up for the loss in settling. The temperature observed at these dates was 140° at a depth of six feet. In another silo, filled with clover and "rye-grass" and "meadow-grass," between June 30th and July 11th, when the cover was put on and weighted, the recorded temperatures were (July 7th) 149° and (July 14th) 158°. The first mentioned silo was opened October 25th, and the ensilage is described as "of a brown color, and of a sweet, luscious odor, *free from acidity*, very much resembling that of ordinary hay," and it was at once eaten by cattle, sheep, and horses with apparent relish.

Mr. James Chaffee, of Wassaic, New York, informed me that from unavoidable delays in filling his silo with fodder-corn, in 1882, the ensilage became so "hot," before it was covered and weighted, that he feared it would be entirely spoiled; but, when it was opened in the fall, the fodder was perfectly preserved, of a brown color, and sweet, delicious odor, without the slightest indication of acidity. His cows ate it with such a decided relish that he had no hesitation in saying it was the best ensilage he had ever made. Last year he followed the usual method of rapid filling and thorough packing, and his ensilage, when opened, was very sour, and in quality decidedly inferior to that made in 1882. Other cases of a similar import might be given, to show that a temperature sufficiently high to kill the bacteria and prevent fermentation can readily be obtained in the process of filling the silo, and that the ensilage under such conditions is of much better quality than when the temperature is kept within the range that is favorable for the development of the acid ferments.

Experiments are now needed to determine the exact temperatures required for destroying the organisms that cause fermentation, under the different conditions presented at the time of filling the silo, and the special methods of practice that may be desirable in the treatment of different crops. This field of experimental investigation is of the greatest practical interest, and we may safely predict that the thermometer will soon be found as indispensable in securing the best results in the ensilage of green fodder as it is now in the various processes of the dairy.



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# SOMETHING ABOUT PLANTS.

BY MRS. MARTHA DE M. GAGE, OF HAVERHILL, MASS.

In coming before this organization to present the subject of plants, I do so with diffidence, knowing that, in an audience like this, there must be many more familiar than myself with the facts which I shall present, and to whom what I have prepared will be a tiresome repetition.

As you have gone about your farms or gardens, you may have struggled with this stone-heap, or blasted that boulder, either for use in building, or to get it out of your way. You may have used the beautiful marble for decorative purposes, or have admired the gems set in gold—lustrous and valuable—and yet, perhaps, have never thought that these stone-heaps, these marbles and gems, were possibly due to some form of primitive plant-growth, some unknown vegetable formation, whose decay was the growth of these minerals. For chemical changes, but faintly understood, lie at the foundation of all growth, whether it were in that chaotic, nebulous state from which it is supposed our globe was evolved, or in the springing up of the simplest flower which we unwittingly crush beneath our feet as we walk in the fields. And this study of the flowers that bloom everywhere, alike in the cultivated meadows or by the dusty roadside, in the tangled forests of Brazil or amid the inaccessible cliffs of the Alps, is one that all may indulge in, from the little child who lies at full length upon the ground and examines the daisy, caring not for cellular formation, axis of growth, or prefloration, to the enthusiastic botanist who takes long journeys and endures great hardships to add one more specimen to an already full herbarium, or one more species to the known orders.

In the study of plants, as a work of God's hand, apart from

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their generally recognized mission of beauty, the first thing that attracts our attention is the difference between the vegetable, animal, and mineral growths. And though there are points where the vegetable and animal kingdoms approach each other so nearly that their absolute boundaries are, as yet, a subject of question, yet many points of difference are so broad and well defined as to admit of no controversy. The principal are these,—their growth, their propagation or multiplication, their forms, and their time of duration or existence. Minerals grow by accretion, or the deposition of particles on the outside, having no internal organism which tends to their enlargement. Plants and animals are nourished by food, which, acted upon by internal forces, is finally converted into their own substance; and by this power of assimilation their structure is developed and maintained. Minerals are multiplied only by subdivision, while animals bring forth young; and plants produce seeds, which are only undeveloped plants waiting for favorable circumstances and situations to present all the qualities of the parent plant. Again: Minerals, except crystals, have no symmetry of outline; they present angles or irregular surfaces, and, when presenting regular forms, are measured by straight lines; while plants and animals have each a proper form peculiar to its own species, usually bounded by circular surfaces, and measured by curved lines. Finally, the existence of minerals is indefinitely prolonged, while living forms have an average duration for every species.

Between plants and animals, as living organizations, there are these differences, also: Plants are nourished by mineral food, and this is transformed by chemical changes into their own substance. Animals universally subsist upon this food so transformed. Vegetable tissues are made up of three chemical elements,—carbon, hydrogen, oxygen. Animal tissues are also composed of these, with the addition of nitrogen. Again: In the lowest forms of plants we find many species composed of a single cell; but animals, even in their lowest condition, exhibit a complexity of construction far higher than this.

If we take up any plant, as, for instance, the geranium, we are struck with the great dissimilarity of the structure of the substance of which it is composed. In the leaf we find certain soft, succulent parts which form the expansion or blade; and a

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fibrous portion which makes its framework, the stalk and veins; in the flower, the gaily colored petals, the delicate stamens, the dusty pollen; and what could be more unlike the flower than the coarse, unsightly root-bark? Let us take up our microscope. We will cut the leaf, and place the edge to the lens. We find, instead of the plain surface that appeared to the unassisted eye, a collection of roundish sacs, looking like little green eggs; and of these the whole substance of the plant is composed, except the stalk and veins. And, because they are closed on all sides, they are called cells. Here is the basis of all vegetable growth, from the tender flower that blossoms only for a day, to the cedar of Lebanon that has withstood the storms of centuries. Every plant-growth, however simple or elaborate, may be traced to this common origin—a cell-work so minute that only by the help of the microscope can we detect its presence. Its elements are few and simple, but the combinations are infinite; and so simple is the mechanical construction, that a child may comprehend it, while the wisest scholar may find ample study in the contemplation of the vital laws which govern its existence.

Of these cells, the walls are formed of a firm, colorless, semi-transparent membrane, and during the whole cell-life they remain closed on all sides. Into the substance of this membrane enter the three elements, carbon, hydrogen, and oxygen, forming cellulose; and within their inner linings is a viscid, semi-fluid substance, containing, in addition, a very small portion of nitrogen, this latter element being always necessary to vital action: here all the vital forces of the plant reside. The forms of these cells vary. Sometimes they have the shape of prisms or cylinders; again they are drawn out into long tubes or filaments; or here they have the form of delicate stars. The cell walls, though entirely closed, are penetrable by liquids, and through them every cell absorbs as much as it needs of the nutriment matter around it, a chemical change occurs, that, necessary to the life and growth of the plant, is utilized, and the useless matter is expelled. When the nutrient matter has accumulated sufficiently for the support of new cells, they begin to be formed. Sometimes this production goes on with inconceivable rapidity, as in the mushroom, where it has been estimated that 20,000 new cells are formed every minute. This cellular

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tissue is called *Parenchyma*, and of this substance all very young plants, the petals of flowers, the pulps of fruits, and a very large portion of roots, seeds, and leaves, are composed. All orders of plants lower than the club-mosses, as mushrooms, sea-weeds, liverworts, lichens, and mosses, are made up of this membrane. They lack a regular axis of growth, and have a tendency to expand laterally.

In the course of development, some of the cells undergo changes by the thickening of the cell-walls, and by the depositing of a new layer, from which, by the evaporation of the water it contains, a solid substance fills up the cavity. Sometimes this seems to be composed of organic matter, as in wood; again, wholly inorganic, as in the stone of fruits. The gritty substance found in some pears is due to this cause, and even the softest and most pulpy fruits always have a portion of these gritty cells. And we know, because flowers leave ashes after combustion, that this is also true of them, for the same material that forms the rock and builds up the mountain, gives its color to the exquisite beauty of the rose, or adds its mineral lustre to the whiteness of the lily. Sometimes this earthy matter is in the form of crystals; and not only crystals, but silex, or the earth of flints, also enters into the structure, strengthening and solidifying. It is this that enables the stalks of grains and grasses to support themselves in an upright position. The family *Equisetaceæ*, known as horse-tails or scouring-rush, affords a remarkable instance. But the most astonishing accumulation of mineral matter in vegetable form occurs in that large class of sea-weeds of the lowest type, which pass by insensible gradations into animal organisms. In these, almost the entire cell-wall is composed of silex, which, as the plants decay, is deposited at the bottom of the waters where they are found. May it not have been, in the earlier existence of our globe, that some of our rock formations are partly due to this cause, being changed by heat and other chemical action into their present forms? We do know that our mineral coal is of vegetable origin, the glandular cells in their petrified state proving them to have been developed from woody fibre, and pointing to the *Conifers*, or cone-bearing family, as their probable source.

When vegetation is reduced to its simplest form, we find that

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the plant and the cell represent each other. And, indeed, some forms of vegetable life are but a single cell. In the *Protococcus*, or red snow of the polar regions, that tinges large tracts of snow-fields with its crimson bloom, as in the rarer green snow, we find the cell-structure in its single, simple form. By another step we arrive at a higher development, where the cells seem to branch, and so build up a finer structure. And no sooner do we find this, than the reproductive organs of the higher orders of plants are foreshadowed, and one or more cells are devoted to the important office by which the plant is to be continued and its species preserved. We find these globular cells to contain other cells or young plants, called spores, which are equivalent to the seeds of the higher species, and which are scattered by the bursting of the sac which encloses them. Yet these never contain the rudiments of a whole plant, as in the true seed of grains or of trees. The leaf-like body, which in ferns and sea-weeds is called a frond, in mushrooms and lichens takes the name of thallus, and is a confusion or blending together of leaf and stem. Who does not know the gray, leaf-like patches on old wood, walls, and rocks? Or who has not found the scarlet fairy-cups on their brittle stems in old pasture-lands? If closely examined, we shall find them to contain, not the nectar of Puck or of Oberon, but the specialized cells which are to scatter indefinitely the reproductive spores, as we crush them in our eager grasp. How many of us have thought, as we seized a puff-ball in our childish play, and made it "smoke," that we were planting for an indefinite growth of puff-balls in the future! In some species of lichens, notably in one form which hangs in long, tangled masses from trees near the sea-coast, are figured the rudiments of a stem. So, in sea-weeds, this stem-like process attains sometimes the length of many feet, but as no woody fibre enters into its construction it cannot properly be called a stem. In the next gradation upward—the liverworts—the reproductive organs become more strongly marked, and the distinctions of leaf, stem, and flower are more clearly defined. The color of the plant shows that the leaf is attaining a normal state by the secretion of chlorophylle, or the green coloring matter of all plants. We also find a shadow of the woody fibre in the spiral elastic threads contained in the *sporangia*, which, sensitive to

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moisture, are influenced by it to expand elastically and scatter the spores. In the next order in our upward journey—the club-mosses—we find the first indication of woody fibre; for, if a plant is destined to rise above the very humblest structure, it must be braced and strengthened by this fibre. Here we have a clearly defined leaf and stem, the leaves, however, so closely overlapping each other that they resemble the foliage of some pines, whence they are called, not unfrequently, ground pines. So we have, belonging to these orders of plants, all varieties of mould, the mushrooms, sea-weeds, and ferns, with lichens, liver-worts, and club-mosses, whether it be the blue mould that worries the house-wife in hot weather, or the tree-ferns of the tropics, which by their graceful foliage and arborescent shapes would mislead in regard to their proper place in the list of growing things. From all these no proper flowers are produced, and hence they are called by scientists *Cryptogamia*, or flowerless plants, because their reproductive organs are comparatively obscure.

And for reverse reasons all the higher orders of plants are called *Phœnogamia*. And here we first arrive at the true typical plant, with root, stem, leaves, flowers, and seeds, all expressing ultimate perfection of use and beauty as developed in the system of vegetable growth.

With the first influence of favorable surroundings, the young plant is acted upon in two different directions. One point takes a downward course, fixes itself in the earth, and becomes a root. The opposite point, as strongly determined upward, rises into air, and produces a stem and leaves. These three contain all that is necessary to the nutriment and growth of plants, and all other organs are but transformations and repetitions of these. That part which determines downward, preferring darkness, hiding itself in the soil, we call a root. The chief bulk of annual and biennial roots is composed of the tissue before referred to, called *Parenchyma*, and the cells of these are subject to the same laws of life and growth as those of other plants, and in some respects have a corresponding formation to that of the stem, according to the use and duration of the stem. In all plants that form woody stems, this woody tissue appears in the root soon after it is formed in the stem. But the fibrils, or

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growing points, are invariably composed of *Parenchyma*. In these fibrils the vital activities of the root reside. The growing tissue is not, however, at the extreme points, but immediately behind them. In respect to the form of roots, the shape varies, but their continuance divides them into annual, biennial, and perennial roots. Annual roots belong to the plants that germinate, arrive at maturity, flower, and bear seed, in their turn, in one season. Such roots are always fibrous. They are only adapted to absorption, and in the rapidity of their vitalization the nutriment collected is absorbed nearly as fast as obtained. Only enough is stored to sustain the process of flowering, and that over the plant dies from mere exhaustion. Biennial roots, during the first season, only put forth a tuft of leaves, and all the extra nourishment they absorb is stored away in the tubers, knobs, and other forms which distinguish such roots; and this nourishment is generally starch, sugar, or mucilage. In the second year a stem and leaves are developed, flowers and seeds are produced, and to the maturing of these all the accumulation of the previous year is necessary, so that the root, being exhausted, dies. Our common root crops are forms of this type. Perennial roots belong to shrubs and trees, and such herbs as cannot endure the severe cold of the winter in temperate climates.

The root derives its food from various sources by absorption, or the power of sucking from the soil the liquids and gases essential to the life of the plant. Plants have a certain power of selection or choice of food from the substances that surround their roots. Thus, from the self-same soil, a beet or potato will take up potash, a clover plant, lime, and wheat, phosphoric acid, for the elaboration of its seed, and silex for the support of its stalks.

Roots also lengthen most rapidly in the direction of the most favorable conditions, seeking, by a kind of instinct, the richer food in richer soils.

We have seen that the universal organic constituents of plants are carbon, hydrogen, oxygen, and nitrogen, although the nitrogen, being only necessary to vital action, is never fixed in the structure. As these four elements are universal, it follows that the distinguishing characteristics of all plants must be traced to

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the inorganic elements which enter into their composition. Of these four elements, carbon constitutes fifty or sixty per cent. of the whole structure. This amount is drawn, either directly or indirectly, from the atmosphere. Oxygen and hydrogen are furnished by rain-water, and nitrogen chiefly in the form of ammonia. But while these organic elements have always been duly noticed by scientists and cultivators, the importance of the inorganic elements has not been appreciated. These are composed of potash, soda, lime, phosphoric acid, sulphuric acid, magnesia, and silica or sand. These, drawn from the soil, may be termed the peculiar or individual constituents of plants, and to determine of what kind, degree, and in what proportion they are combined in any plant, we have only to analyze the ashes deposited in burning.

Thus we arrive at certain conclusions in regard to the food necessary to be supplied; for the inorganic elements, which in a natural state are taken up into the plant, should not only be present in the soil to which the seed is consigned, but in the same proportions as are contained in a healthy plant of any given species. Liebig, the great German chemist, has made many experiments in this direction, with a view to just and certain laws in agricultural operations. He classes cultivated vegetables under four heads, viz.: Alkali plants, represented by potatoes and beets; lime plants, as clover and pease; silex plants, as grasses; and phosphorus plants, as wheat and rye. And while the organic bases have been abundantly supplied by the organic remains of which manures are generally composed, and which constitute a large portion of rich, black earth or humus, little attention has been paid to the necessary supply of proper material for supporting the inorganic bases. For we cannot, by any process of fertilizing, change one element into another. This explains the necessity of a rotation of crops, for the whole secret lies in regulating the soil to the condition of the crop desired, or the reverse in adapting the crop to the soil. This absorption is performed chiefly by the fibrils with which the root is abundantly clothed. These parts, having no epidermis or thickened outer membrane at the extremities, absorb liquids with great power, until the root is completely saturated with moisture and other elements from the surrounding soil. The

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way in which this force operates was long a mystery. The ascent of sap was contrary to the laws of gravitation. It could not operate by capillary attraction, because there are no continuous tubes in the vegetable frame, only closed cells and short interrupted passages. Yet a mode of circulation was found to be favored by these very closed cells. This method, discovered by Dutrochet, is termed endosmose and exosmose, and may be explained simply thus: "Two liquids of different densities, separated by a membrane, attract each other, and currents will be established; but the attraction from the denser liquid to the weaker will be the stronger, and in proportion to the difference in density. The principal current will be inward flowing, or endosmose; the other, outward flowing, or exosmose. So the vegetable cells contain a liquid denser than water, holding the assimilated juice mingled with crude sap. This, attracting the water from outside by this law that tends to the equilibrium of densities, flows inward." But that the counter current is also established is shown by the fact that a plant grown in water imparts some of its peculiar properties to the liquid which it inhabits, and also that by carefully analyzing the soil around any plant we find the earth more or less impregnated with the properties of the plant. Yet, though this principle is established beyond a doubt, we must not forget that the vital principle is always superior to mechanical laws. Galvanism has been considered by some as the agent of this transmission. The flow of sap is always most rapid when the vital action is strongest. Light, heat, electricity, and winds accelerate the vital forces, and produce some remarkable results, which they could only do by reason of the existing vitality; and this moving power stands back of all; for the plant, in being vitalized, passes out from under the common laws of dead or inert matter.

We come now to the growth of the stem. This, as before defined, is that part of the plant which, seeking light and air, develops upward. It grows by the extension of its whole substance, and by the development of woody fibre. Some plants, as the lily, grass, and palm tribes, grow from the inside, and extend their growth laterally no longer than while the stem remains soft and capable of distension. The new cells are indistinguishably mingled with the old, as they are formed in the

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centre, but when the stem is no longer flexible and yielding, the vital action pushes upward. Hence palms and other endogenous trees are distinguished by their lofty and slender frames, at once so majestic and so graceful. There is this distinction also, that as palms do not form lateral buds, if the terminal bud is destroyed, there being no means of reproducing it, they decay and perish. A grove or avenue of palms is said to form a magnificent sight, notably one at Rio Janeiro, where an avenue of several thousand trees forms a favorite promenade for the people of that city, and where the stems, rising to majestic heights, seem like a row of polished silvery columns, crowned with tufts of waving, graceful leaves, casting but faint shadows in the moonlight, and receding in the distance, growing smaller in perspective till they fade from view. One familiar with this avenue describes its intense regularity and monotony of form as fatal to lively emotions, and producing only a feeling of melancholy that accords well with the exuberant growth of the tropical scene.

In the exogenous or outward growing families, we find the stem divided into distinct and separate layers,—the pith, wood, and bark. The pith, in young stems, is filled with nourishing juices, but as the stem grows it is pressed inward, and either becomes dry and spongy, or is entirely obliterated. The old wood, or heart-wood, as the tree grows stronger, appears merely to give mechanical support to the tree, and preserves the unity of the system by keeping the form entire. This woody tissue, or *Prosenchyma*, is composed of elongated cells, pointed at both ends, and overlapping each other, so as to form continuous fibrous threads. It is owing to this circumstance that wood will not "split across the grain." These threads are crossed over and through by other cells, usually, though not always, connecting the pith and bark, not in directly vertical layers, but showing slight curves and flexures, according to the manner of growth. These are the remains of the horizontal system, and have been compared to the woof of a fabric, as the longitudinal fibres compose the warp. In the oak and maple, although the cells themselves are invisible to the naked eye, they form conspicuous lines in the cross section, and impart a beautiful silvery lustre.

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Next the heart-wood, outward, lies the sap-wood, and here the growing forces of the wood exist, and whenever the distinction between the heart-wood and the sap-wood or alburnum is strongly marked, we see a distinct and definite color, as in the yellow hue of fustic, the black of ebony, the rich, dark red of mahogany, and the varying colors of black oak and hickory, all these beautiful hues being found in the heart-wood alone. Between the wood and the bark is a stratum of extremely delicate and vital cells which belong equally to both. This develops wood on the one hand, and bark on the other. This cambium layer, or thickened sap, in pines has been the delight of many a boy and girl in the spring, under the familiar name of "slivers."

When the bark just begins to be formed, it is soft and composed entirely of *Parenchyma;* but as the stem forms woody tissue, fibres are also distributed in the bark, the inner layers of which become fibrous, while the outer layer loses its greenness and becomes gray. This bark has three distinct layers. The white, inner formation is called the liber, not only because it exfoliates in thin sheets, like the leaves of a book, but because the liber of many trees has been used for writing, instead of paper. The fibres of this integument are long and very tenacious, are usually called the bass tissue, and are the longest cells in the vegetable structure. The most familiar instance of this with which our farmers are acquainted will be found in the Russia mats with which they shelter their hot-beds, and which are made wholly of this fibrous, inner bark. And while the cell-walls of the wood may be marked by dots, or spiral fibre, these are not found in the bass cells of the bark except in a very few species, as in the milkweed of our roadsides, and in the oleander, a plant nearly allied to the milkweeds. A knowledge of this fact enabled Prof. Schleiden, of the University of Jena, to determine what plant produced the bit of string that had been tied around a wine-vase in Pompeii, which proved to be our common milkweed (*asclepias syriaca*): so indelibly are the truths of nature inscribed, and so may they be read without a mistake after the lapse of ages.

The cellular, or middle layer, does not usually increase after the first year or two, and by the thickening of the corky deposit, or outside layer of bark, it is deprived of light and so of the

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formation of chlorophylle, and thus gradually perishes, never to be renewed. To this corky envelope the peculiar colors that distinguish the various trees and shrubs is entirely due. It is this which falls in continuous sheets from the birches, or hangs in strips from the hickory and elm. The same circumstance which solidifies and makes the wood durable, contributes to the destruction of the bark; for, while the growth of the wood is rendered compact by inward pressure, the bark is distended and torn by outward pressure, and is constantly changing by the corrosion of the elements without. The dead parts fall off in layers, and as the cells of the bark soon cease to grow, the proportion of bark to wood becomes less with the age of the tree.

We come now to the bud: and a tree should not be considered an individual, but as a compound being, consisting of as many individuals as there are buds, for each contains the rudiments of a new growth, which it holds in a latent state, until favorable circumstances warrant its development. The trees and shrubs of warm climates do not form scaly buds, but unfold their leaves directly to the air. But whenever there is snow or frost a part of the year, buds are formed for the protection of the latent plants. In the structure of the bud is found one of the most beautiful provisions of life. The young plant is covered with a coat of downy fibre, with layer upon layer to make it soft and warm; its roof is thatched with stronger folds, and over the whole is spread a coat of resin, which renders it impervious to cold or wet. Thus wrapped it rests securely, until, by the warmth of spring, its vitality is excited, and it comes forth to join the troop of dancing leaves, or to assert its individuality in a new life. By the development of this bud a new section of stem is produced, still terminated by a bud, which finishes and crowns the annual growth. In some trees, as the birch or cherry, the principal stem maintains its ascendency; but usually, by separate ramifications, it becomes indistinguishably merged in its own off-shoots, forming a head, as in the apple-tree. The leaf-buds of many trees are very beautiful in their expansion. The horse-chestnut, with its leaves and flowers, is a conspicuous example. But the finest among us is found in the walnut, the buds of which resemble a half-blown tulip, whose petals have a texture of the richest velvet, varying in color from a flesh-white

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to a tinge of gold, relieved and softened by a faint blush-red, or a hue of ashen-gray.

After the leaves are developed, we are struck at once by their diversity of form, size, and texture. We see the stalk and veins composed chiefly of woody fibre, supporting and strengthening the cellular tissue which forms the flattened surface of the blade. In some, which present all their surfaces to the light, as in the pine or iris, there will be no difference in the outer integuments; but in others, which present one surface to the earth and the other to the sky, we shall find the upper surface usually firmer, smoother, and more compact, while in the lower surface the cells are more loosely arranged. If the plants live in a dry, arid atmosphere, we shall find a structure calculated to retain for a long time all the moisture they may acquire. If, on the contrary, they live where abundant moisture can be obtained, the texture of the leaf will allow of the exhalation or evaporation of the superabundant moisture. We see, on many plants, short, hair-like processes, which are the organs of exhalation. They resemble self-acting valves, sensitive to moisture. When there is an excess of water in the plant, they elongate themselves, curving outwardly, so allowing the passage of the superfluous water. Where there is a deficiency, they shorten, and straighten, and so prevent exhalation. They are generally too delicate to bear the full sunlight, so are chiefly found on the under surface of the leaf. They are very numerous, so that 120,000 have been counted in a square inch of surface.

A knowledge of leaf forms is necessary to the discrimination of species, and these it is not necessary to enumerate or describe, for that could not be done within the limits of a single paper. The leaf-stalk in temperate climates is usually rounded on its lower side, and grooved at the top. Sometimes it is flattened from the sides, as in the white poplar or American aspen, where the thin, dilated petioles, being acted upon by the slightest disturbance in the air, keep the leaves in perpetual motion when the leaves of the surrounding trees of other species are still. This leaf-stalk or petiole sometimes undergoes most remarkable modifications, as in the *Sarracenia* or pitcher-plant of our wet meadows, where the dilated petiole, becoming infolded upon itself, coheres at its edges, forming a tube which is nearly always filled

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with water, while the small lip-like process at the top is the proper leaf. In the water-chestnut the petiole is formed into an air-tube which buoys up the floating leaves. But there is nothing of this kind more curious than in a twining plant of the East Indies which has been described by botanists. This plant, the *Dischidia*, ascends the tallest trees, putting forth leaves sometimes one hundred feet from its base. The whole stem below, being without leaves, can elaborate no food. The pitcher, with its adherent edges, entirely closed at the bottom, receives and retains all the moisture that comes in its way. From the nearest part of the stem several root-like processes are sent out, which, entering the little cups, absorb the stored-up moisture, and so sustain the upper part of the plant, which for want of leaves below would doubtless perish.

That leaves are more than clothing to the plant will appear when we know that their most important offices are absorption of necessary food and moisture from the air, digestion of the crude sap which flows to the leaf from other parts of the plant, and exhalation of the superabundant or hurtful elements. By this digestion plants accomplish one of the most wonderful results in nature. By changing inorganic material into their own substance, they convert it into food for men and animals. They stand at the basis of life as the only nourishers of the world, for men and animals consume what they so bountifully provide. They also accomplish another most wonderful result, for oxygen, the most important atmospheric principle for the support of animal life, is liberated by them by means which as yet no chemist can imitate, while carbonic-acid gas, that noxious principle so baneful to animal life, is the vital principal of the air for plant life. So each organic kingdom maintains its beautiful relation with the other, each harmonizing with and counterbalancing the other.

We arrive now at that most beautiful of all developments in plants, called infloresence or flowering. A complete flower consists of the essential organs and their envelopes. These are the stamens and pistils, or fertilizing and seed-forming organs, and the calyx and corolla. In some plants the stamens and pistils are in separate flowers, as in the hickory. Again, they are in distinct plants, as in the poplar and willow trees, and in the hop

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and strawberry. All these floral organs, unlike as they are to each other and to the leaf, are in reality only transformed leaves, and to the ordinary student these transitions are very clear, as in the tulip or lily tribes. By excessive nutriment in cultivation and other unnatural stimuli, the stamens and pistils are changed to petals, producing double flowers, as in the rose, and we shall always find, as we approach the centre of the flower, that the petals become narrower with various foldings, until imperceptibly they pass into stamens and pistils. But nothing is more curious in the flower, or impresses one with greater wonder, than the continual recurrence of a given number in the parts of a flower. Thus, if a certain flower has four, five, or ten stamens, all the perfect individuals of the same species will have, as a matter of certainty, the same number; and if at any time this number is not complete, we may know that some accident has disturbed the original and perfect type. Of the methods of prefloration and subsequent expansion of the flower it is not necessary to enter into detail. These the student must learn for himself; but we are more attracted by the color and odor of the blossoms than by any mathematical regularity of form. Pliny long ago called blossoms "the joy of trees," and there is not less of truth than poetry in the sentiment; and though there is in the foliage of the vegetable world that hue which is most grateful and soothing to the eye, the finest tints and most lovely combinations of color are reserved for flowers. Transient as they are, the tints of flowers often undergo changes in their brief life. Red, purple, and blue flowers sometimes become white, and yellow under the influence of light sometimes assumes the same color. The most familiar instance of this change is in the hydrangea, which opens a pea-green flower, and afterwards appears white, yellow, pink, or purple. Between the color and odor of flowers there is sometimes close connection. This odor is due to a volatile oil, which is excited by moisture, and is usually most freely given in the evening, when the air is laden with dew. And it will be noticed that in flowers of the same color there will be a remarkable similarity of perfume. For instance, in that class of flowers called by Linnatus "melancholy flowers," characterized by greenish, yellowish, or brownish tints, the



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fragrance is powerful and delicious, as in the wall-flower and evening-primrose.

There will be no need of elaborate specializing in regard to fruit or seed, its kind, shape, variety of form, or excellence, or of the fertilization of flowers in order to the production of the highest types. For in an institute like this, whose leading members have made a life-study of producing and perfecting rare vegetables, or fruits of superior excellence, time and words would be wasted in explaining. So of the germination of seeds: I do not suppose there are many present who have not at some time pulled up a shoot to see how it grew, and who do not know that in the thickened, fleshy cotyledons, concealed within the outer bark or shell, are stored the sugar, starch, albumen, and other substances necessary to the sustenance of the young plant, until the growth of its roots and the formation of its leaves enable it to take care of itself. The periods that elapse between the time of planting and the germination of seed vary, as does the length of time that their vitality is dominant. Cabbage will germinate in two days, turnips in three, grasses in a week, some pines in a year, and the holly and date-palm in two years. Some seeds lose their vitality as soon as they fall from the plant: others are very tenacious of life. The seeds of grasses often retain their vitality for a long time. Maize and rye will germinate after forty years, and kidney beans retain their life principle for a century. Seeds with hard, thick covers or shells, keep longer, while fleshy, pulpy fruits are extremely perishable. Dr. Lindley, the great botanist, raised raspberry plants from seeds which were taken from the stomach of a man whose skeleton was found thirty feet below the surface of the earth. With the body had been buried some coins of the Emperor Hadrian, who reigned A. D. 117 to 138. Within a few years, grains of wheat obtained from the Egyptian catacombs, where they are supposed to have lain not less than three thousand years, have been planted in England, germinated, and produced abundantly.

Many circumstances assist in the dissemination of seeds. Some, with elastic pericarps, burst and scatter their seeds in every direction. Some are furnished with hooks and spines, like the teasel, or the familiar beggar-ticks or burr-marigold. Others, like the seeds of the ash, beech, or maple, are fur-

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nished with wings, and fly away. The plumose appendages of the thistle, dandelion, and other compositæ, waft the seeds to a great distance in the air. Some follow river and ocean currents. A seed of robin's-plantain was carried across the Atlantic in a stuffed bird, in the seventeenth century, and it has overspread all Europe. A similar instance is furnished by the cardoon-thistle, a native of northern Africa, the seeds of which, having found their way across the sea to La Plata, their progeny have overspread the great pampas of the Cordilleras for two hundred miles in every direction, forming in some tracts, with their stout stems and spinescent leaves, impenetrable barriers, sufficient to repel an invading army. Thus does the All Wise guard the life he gives, not only by throwing around it innumerable barriers, but by placing its whole force in direct antagonism with death, so that all its instincts and tendencies repel decay and resist dissolution.

By far the most important part which plants bear in their lives is found in their use to man. We have spoken of their benefit by the exhalation of oxygen, and the absorption of carbonic-acid gas from the atmosphere. In the roots of some we have a wonderful substitute for bread;—and in the first rank comes the potato, rich in starch, originally a small, rank tuber, native in Pennsylvania, but now a necessary staple of food to the greater part of the civilized world; the sweet potato, a staple of food in several South American countries, especially in Guiana. The cassava or manioc root, also a tropical American product, furnishes the natives, when baked, with a wholesome and excellent bread, with wourali, a deadly poison, for their arrows, and an article of commerce, the familiar tapioca. The arrow-root, prepared from a species of maranta, is said to derive its name from being used by the Indians to extract the poison of arrows. In our own climate, the carrot, parsnip, and beet are rich in saccharine matter.

Many roots possess aromatic or medicinal qualities, as ginger, calamus, and sweet-flag. The two former belong to the aromatic lilies of the East, with foliage soft and rich as velvet, and vivid, intense flowers. Of the bark on the roots of the guentec, a climber of La Plata, a rough cordage is made. Then we have the dyes, madder, alkanet, and turmeric; and the roots of many

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other plants, both native and foreign, are rich in medicinal qualities.

The first uses of the stem are those of fuel and for building, and for purposes of ornament. We have the mahogany from tropical America, ebony from Madagascar and Ceylon, and our own oak, black walnut, bird's-eye maple, cherry, and birch. The bamboo is an arborescent grass. It furnishes food from its tender shoots, paper from its macerated stems, while from its full-grown stems are made flutes, canes, and umbrella-sticks, as well as boats, boxes, and fences. From the ashes of the harder kinds of wood we obtain potash, which by refining gives us pearl-ash and saleratus. We have the dye-woods,—logwood, camwood, Brazil wood, and fustic,—which with mordants give various dyes and shades of color, and which are brought from Africa and Central America. Sago is prepared from the pith of some palms. The bark of birch trees is used by Indians for boats and for roofs for their wigwams, and in some parts of Russia for sails for boats; while an oil from one kind of birch is used in making Russia leather. The astringent property of oak and hemlock is also used in making leather. Our bonnets are made of the stalks of rye and grasses. Our ink is prepared with the gall-nuts formed by the puncture of an insect on the tender shoots of an oak in Asia Minor. Cinnamon is the dried inner bark of a species of sassafras from Ceylon. The bass fibres of flax and hemp furnish us with linen cambric and cordage, while from the bass-cells of a species of pine-apple from Mexico, the beautiful and delicate pina-cloth is made.

The uses of the leaf are also manifold. Some species of palm furnish a variety of articles. The leaves of the papaw are used as a soap. Tea, an article of prime necessity, is the dried leaves of a Chinese shrub, and the drug known as senna is from the leaves of a species of cassia.

From the flowers we obtain drugs, dyes, and perfumes, as opium from the poppy, saffron from a species of crocus, and the delicious "otto of roses" from the roses of the East. The clove is the unexpanded flower-bud of a small shrub growing only in a small cluster of the Molucca Islands. The tree resembles a laurel, and it is said that no verdure is ever found beneath it.

The uses of the fruit, generally speaking, are well understood.

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Coffee is the berry of a small shrub native in Arabia, and the best still comes from Mocha in Arabia Felix. Chocolate is prepared from the seeds of the theo-broma cacao, the name signifying the "food of the gods," a small shrub of the Amazonian valley. The fruit of the olive yields oil, and in a green state is pickled. The breadfruit and cocoa-nut furnish food for the natives of the countries where they grow, as do the banana and plantain. The date-palm and fig should not be forgotten, nor the lofty and beautiful tamarind.

Foremost among the seeds are the cereal grains, wheat, maize, and other plants of this class, and the leguminous seeds, as beans and pease. The seeds producing oil are those of the flax, walnut, castor-bean, sun-flower, and cotton-seed. Nutmegs are the seed of a drupaceous fruit of the East Indies, and the scarlet aril surrounding the seed is known as mace.

Sometimes the whole plant is used for food, and first among those are the grasses, which not only carpet the earth, but furnish food for herbivorous animals. The Iceland moss is a lichen, and the Carragheen moss an alga, which, from the gelatine they contain, are much used in cookery.

The juices of plants furnish a variety of products. In the forests of British Guiana is found a tree called by the natives hya-hya, the pith and bark of which are saturated with milk. But by far the most remarkable instance of this kind is that of the South American cow-tree (*Galactrodendron utile*), first made known by Humboldt. When an incision is made in the trunk of this tree, a sweet, fragrant, oily liquid flows forth, very similar to animal milk, and in sufficient quantity to refresh and satisfy the hunger of several persons.

Resins, gums, and balsams may be classed as exudations. Gum-Arabic and gum-Senegal are the products of the acacia tribe of northern Africa and Asia Minor. The beautiful coloring known as indigo is from the fermented juice of a leguminous East Indian plant. The dyer's-weed, also leguminous, yields a beautiful yellow. Onotto, a well known orange dye, is an extract from the juice of the *bixa-crellana*. Pitch, tar, and turpentine are resinous products of the pine family. India-rubber abounds in the nettle-worts, spurge-worts, and dog-bane families. Gutta-percha is a similar product from a tree in the

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Indian archipelago. The glaucous bloom of fruits is a thin coating of wax, which not only gives them their gloss, but protects them from injury by water. It is found on the stems of the bayberry in sufficient quantity to be collected and applied to various uses. Varnishes are resins, dissolved in either oil or alcohol.

From various plants we derive vegetable acids, as malic acid from pears and apples, citric acid from lemons and oranges, tartaric acid from grapes, oxalic acid from many plants (it being specially abundant in the wood-sorrel, hence the name of the *genus-oxalis*). Prussic acid, a deadly poison, is found in the leaves, bark, and kernel of the peach, plum, and cherry; tannic acid in the oak, birch, and hemlock. This latter acid abounds in many old barks, and is probably the result of decomposition.

The alkaloids are possessed of most active properties, and many of them are violent poisons. Quinine, the bitter tonic of Peruvian bark, morphine, the anodyne principle of the poppy, strychnine, the terrible poison of *nux-vomica*, nicotine, the poison principle of tobacco, and coneine from the poison hemlock, are all alkaloids.

So we may say that there is no art among us, nor any condition or circumstance of life, which does not depend upon the vegetable world for its materials or sustenance, in some form or other. Plants are the first workers, the first providers; they are the great chemists of the world, transforming the crude mineral substances into the elements of organic forms. Stationed at the basis of all vital activity, they are constantly extracting from the earth and soil the elementary and sustaining principles of life.

We should not look upon the study of plants as a bundle of dry facts, hard names, and severe principles, but as a series of living truths, through which the mind may develop and strengthen by actual contact with things quick with life and beauty, so attaining that free and generous expansion which is the highest happiness. For as the love and observation of flowers are among the earliest phenomena of mental life, so should a correct knowledge of them be among our earliest teachings. And with knowledge of forms, habits, and methods of growth, would come a sense of treasures of thought, awakening a desire to know more of the mysteries of Nature, investing us with the power of

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transforming the most common weed into one of the most beautiful creations, instinct with divine life. For in studying nature we are brought nearer to that divine power which everywhere underlies and breathes through every-day things, mutely speaking of the wisdom and infinite goodness of the Creator.

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# FARMING MADE ATTRACTIVE.

BY JUSTIN E. BURBANK.

In considering the topic, How to Make Farming Attractive, our attention is called, not to the agriculture of other countries, or to the broad prairies of the western portion of our own widely extended domain, but to the narrower limits of our own state.

The prosperity of this branch of industry is of great importance in its relation to all that concerns the vital interest of that political division where we have our home, where we have, the most of us, had our nurture, where our affections and hopes centre, and where we expect to live out our lives and lay our bodies to rest.

The many obvious advantages of agricultural pursuits do not create in the natives of our soil that strong attachment to it, as a life-long pursuit, which is sometimes seen in other climes. The youth inquires how he can most quickly and advantageously desert the occupation of his ancestors, and embark in some other calling. His steps naturally tend towards the city, flourishing in the abundance of its resources and the enterprise of its inhabitants. And all this in spite of the fact that agriculture is carried on in the open air, with all the advantages of breathing a pure atmosphere and of constantly beholding the varied and charming aspect of the skies above, as well as the scenery rejoicing in its own beauty, which so often makes up the landscape spread before him. The leisure that the farmer frequently enjoys is considered of no account, and the pleasures of home and fireside, with the affection and repose which receive their nurture there, are thrown into the scale as weights of too small value to have any effect in determining the balance.

The result of this low estimate, placed upon the cultivation of

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the soil, is seen in the homestead abandoned, the cultivated field becoming pasture land, the pasturage lapsing to wood-land, and the general decay of the enterprise and public spirit of a community that was once full of the vigor of prosperity. The result is not only a numerical loss to the population, but the growth of a spirit of discontent and discouragement among those who still remain to keep alive the ancestral fires, and preserve a reverence for the burial-places where slumber former generations.

Farming is still a leading pursuit among our people, though not, as in the infancy of our existence as a body politic, almost the sole means of acquiring a livelihood. We welcome to prosperity in the midst of us every other honorable avocation, but regret to see any falling off in the occupation of our early inhabitants. It is from the earth that all value must come, and a large part of it through the medium of agriculture. The majority of our people are still dependent on this most honorable calling for the possession of all the property they will ever enjoy through the labor of their hands, or by inheritance from those who have toiled before them, and into whose labors they have entered. The importance and interest of the theme I have chosen become at once obvious to a consideration even very slight. Neither we nor our children ought to despise a pursuit that is so prominent on account of its necessary connection with the general prosperity of the state that gave us birth, and that we cherish with filial affection.

We may affirm, without the least fear of successful contradiction, that one of the chief reasons why men forsake the farm for some other business lies in the conviction that there is more profit somewhere else. The temptation of gain has a potent influence with everybody. When men conclude that there is little to be gained by tilling land, the very next question they ask is, How can we escape from this pursuit, and engage in some other that will be more remunerative? While some more fortunate farmers secure a competence, and even an abundance of that which all men desire, many are every year on the verge of actual loss, and some have an appalling balance against them at the season's close. It will be a Herculean task to make agriculture attractive to this unfortunate class. The attractive

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force is all in an opposite direction. We may say, at the outset, that farming, to be attractive, must be made in some degree profitable. The gaunt wolf of famine must be driven from the door, and some small resources must remain to be expended in the gratification of taste, or no pursuit can long remain pleasant, or even tolerable, to those engaged in it.

Farmers in New Hampshire, if they would secure the first condition of an attractive pursuit, must practice economy in carrying it on. A reckless and expensive style of management will be sure to wreck their fond hopes, and inevitable disgust will be the certain result. In some parts of the United States, a farmer with an almost princely estate of virgin soil might scorn the idea of a calculating, miserly scrutiny of all his modes of accumulating and spending his income as the years go by. But many among us are obliged to take this very repulsive course, or, like the Arab, "silently fold their tents and steal away." The owner of a large and productive farm in our state may find room for liberal expenditures and costly modes of culture; but the small proprietor must away with all this, or the sheriff will away with the most of his scanty possessions, and he come to the conclusion that, however poets may have sung the praises of a rural life, it is far from possessing attractions for him.

Economy must be manifest in the selection of the ground he will cultivate. That on which he bestows the labor of his hands, which consumes the sweat of his brow, should be the choice spots of his whole estate. Let the poorer parts go to the production of wood or pasturage. But let him seek out carefully all the uncommonly good bits of soil, where is found a rich loam, or an unusual depth of fertile earth, or where the cultivation may be accomplished with the most ease, taking into account, of course, the situation as to distance from his buildings, and ease of access. No economy will pay better than this.

Economy may be shown in the use he makes of the timber that grows on his land. After reserving all he needs for woodland, and all the maples he can use for the manufacture of sugar, let him consider what most profitable use he can make of the remainder. If he can turn it into money for the fire-wood or the lumber it produces, let the woodman's axe ring sharply among

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the ancestral groves till all are laid low, unless there should be reserved some clumps of shapely trees to please the eye or furnish a grateful shade.

The farmer must next inquire how to save the most in the arrangement and material of his fences. If he already has a well built stone wall, wherever he needs any division. his work in the matter of fences is done mainly for all time. If he is less fortunate, and cannot supply the want, then comes the opportunity for economical and wise planning in reference to the enclosures he will establish on his land. He will not be obliged, it is to be hoped, to fence along the highway that runs through or by the side of his real estate. If possible, let him have his pasturage and his arable land lie each by itself, and then he will generally be able to dispense with intervening lines that divide each portion, thus saving much expense of labor and material No economical farmer will construct a fence without carefu consideration of the cost and durability of the material he is to use for this purpose. We hope he will never hesitate to abandon the old-fashioned brush fence, which is so wasteful in the matter of material and labor required to keep it in any serviceable condition. Wire, or rails, or boards, or anything else imaginable, is better for the purpose of an enduring, labor-saving fence, though it be through a thick forest.

A wise man will not scorn to show a spirit of calculating economy in reference to the teams he employs on his farm. If his crop of hay and grain be at all restricted, the keeping of an unnecessary horse or yoke of oxen may become a serious hindrance to his prosperity by using the sustenance he needs for the support of a dairy, or for the growth of stock to be sold for cash or its equivalent, and thus make his business remunerative and encouraging. The useless team may sap all the profits of which he is able to assure himself from his toilsome occupation. The rule he should adopt ought to be, just as little spent for a team as will suffice to accomplish the absolutely necessary labor on his farm and the indispensable travel for his family.

An essential part of economy in farm management will be found in the careful saving and appropriate use of manures that must be applied in order to fertilize every kind of soil that has been subjected to the draught of continuous production. No

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land can always give and never receive. Manure to the soil is the food upon which its annual productive power subsists, and upon which it depends, as the health and strength of an animal depend upon the nutriment it absorbs. The farmer needs especially to care for his stable manure by protecting it from loss through exposure to the weather. Wind and snow and rain sometimes sweep away much of the fertilizing power upon which the farmer depends; the coarser portions are left behind with the principal bulk, but what there is has largely parted with its virtue, and so the ever-laboring soil is robbed of its necessary support. Liquid manure that might be absorbed by some other substance is allowed to run to waste. Commercial fertilizers, which might often be employed with profit, are often neglected, as if there were no such thing in existence, or as if there were an all-sufficient supply of every requisite manure for all the different crops under cultivation, during the entire year, without going beyond the limits of the stable or the farm. Economy in using manures will not generally mean the most profuse application of them to the end of producing an abundant crop. With anything that approaches an available soil, accompanied by a culture that involves a fair proportion of the needed care on the part of the farmer, the generous use of chemical manures, the best the market affords, will commonly prove a good investment. It involves little increase of labor, and sometimes increases the per cent. of income upon that labor, which must be bestowed even without it. The question for the farmer to ask is, What is the amount of manure which I can use without a loss? A pecuniary loss in the cultivation of a given surface in any year is presumably, though not always, a dead loss, for the subsequent year or years may transfer the balance to the side of profit instead of loss. The wisdom of the farmer will appear in the use he makes of the manure he possesses, and in the purchase of that which he may profitably use; and this will largely determine the question of profitable farming, in a state that needs as many fertilizers as New Hampshire.

Finally, and most important of all, the farmer must show the most exacting economy in the use of his physical strength. It was given him to use, but not to use up. It ought to be his life-long possession. Some men have much more than others, but

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none has any to waste. It is each man's capital, to be watched over more carefully than his real estate, and treasured more jealously than his personal property. When it is gone, neither farming nor any other pursuit can be made attractive. It is the bloom and fragrance of the flower which departing leave only withered foliage. With careful attention devoted to it, the toiling farmer may preserve his health and strength, and enjoy the happiness that flows from it for many years. Without it, how soon his life becomes the "sere and yellow leaf." It is excessive rather than constant labor that breaks a man down, and finally makes all labor a torturing burden. A careful measure of one's strength, and an equally careful adjustment to that measurement of the labor to be performed, are the sole means of securing the farmer's natural vigor to the period of age that hastens upon him with each revolving sun. All labor-saving machines will be warmly welcomed by every wise farmer to his relief from some of the heavy burdens of his avocation. Horse-rakes, mowing-machines, threshing-machines, and many other contrivances, are priceless gifts which an age of invention has made to the farmer, especially the farmer of moderate means. He who does not in every possible instance avail himself of such helps, is foolishly sacrificing himself to some groundless prejudice or mischievous theory.

But everything is not attractive, to a high degree, that economy has made fairly productive of gain. Though there be some profit in agriculture, some men will be inclined to forsake it for another pursuit. To add to its attractions, let the farmer, so far as in his power, exhibit good taste in everything belonging to his buildings, his premises, and his entire neighborhood. Good taste is a different thing from abundant expenditure, though it will involve some degree of cost. If the farmer has begun with the practice of a wise economy, he may have acquired the ability to expend something a little beyond the limits of absolute necessity in his mode of life.

But good taste will not be so much a matter of expense in time or money as of good judgment in the use of both. It is consideration and wisdom put in practice that will develop the taste requisite to make the farmer's life attractive, so that he will experience comfort and contentment. There is no remark-

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able expense involved in preventing the accumulation of unsightly objects about the house that one calls his home. Old broken down carts, wagons, carriages, and rubbish of any kind, tend to make an abode far from attractive, and have more to do in producing discontent than we are apt to believe. Let it be an imperative rule with the agriculturist that no such thing is to be allowed, and the matter will take care of itself without much time or expense. Habit makes things easy, and this habit will soon become a second nature. The buildings, both house and barn, may be kept in good repair and painted some appropriate color, not only without extravagant expense, but even with economical advantage, if good judgment be used. Shrubbery adorns and blesses a home, and the expense is by no means enormous, nor the skill required beyond the capacity of an ordinary farmer, if he only has the will to make his dwelling-place tasteful and attractive to his own family and to all beholders.

Why should not neighbors combine for the purpose of adorning the way-side with trees, such as the vicinity affords in abundance? It would not lie beyond the power of organized effort to accomplish an end so desirable, though at first sight the task seems great. We need not say that such an improvement would change greatly for the better, and add new charms to those already possessed by almost every section of country. Those who have a home should love it enough to beautify it to this trifling extent.

The culture of fruit by the farmer is an attraction that he should by no means despise. Almost any New Hampshire farm may be made productive in this direction, if only a small degree of attention be devoted to it. Apples, pears, grapes, the small fruits, nearly all of them, may be raised on almost any farm. Every man who possesses a dozen acres of land is inexcusable if he has not an abundance of apples of choice varieties. It requires a few years' growth, and will be, if not to our own personal advantage, a great benefit to our children, or those who possess the property after us, and, in fact, doubles the attractiveness of any farm. No matter what else it may present, if it has no facilities for fruit-producing it creates in us a feeling of its barrenness as we contemplate it, and causes within us the growth of a feeling exactly opposite to that which is attractive, and the

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charms and real value of such a place, in our estimation, suffer a material lessening.

Facilities for acquiring a fair education are within the power of nearly every neighborhood of farmers. The opportunity enjoyed may not equal that of the city, but may be made to approximate to it much more than is sometimes done. A school properly estimated and sustained will be a possession that can by no means fail of being an ornament and an attraction to the rural neighborhood which is without some of the advantages of the city. A system of instruction that shall furnish a good training in the fundamental principles of all good culture should be aimed at with a strength and steadiness of purpose which shall make it the pride of those who support it and enjoy its privileges. From such sources high scholarship and real discipline spring more often than we suppose, and are frequently remembered with great satisfaction by those who once esteemed them very humble instruments in developing the intellectual power with which nature had endowed them. No fair degree of expense should be spared in order to make the secluded district school-house, in its comfort and comely appearance, and in the instruction there furnished to all who are of suitable age, one of the attractions long to be remembered and prized as associated with the life of the farmers resident about it.

On the other hand, the means of instruction may be so despised and stinted as to bring to the memory no sensation of pleasure enjoyed or of time improved, but, instead, a feeling of lost opportunities, painfully suggestive of minds without cultivation.

Other means of acquiring knowledge may be used by those who expect to spend their lives in cultivating the soil as their chief business. The public library is an attraction to many a country town, and should be to many more. Newspapers and magazines are borne at a trifling expense to every portion of the land, and a daily paper from the city is within easy reach of many farmers. Knowledge in the shape of issues from the press is almost crowded upon the rural neighborhoods, and it is the fault of the farmer, who often has more leisure for reading than the inhabitant of the city, if he remains ignorant of that which he must know in order to be classed among intelligent men. The debating club is not yet an entirely forgotten institution,

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outside of cities and large villages, and is certainly an attraction that is superior to many of the so-called amusements of the city.

Men in rural neighborhoods may be social. Society is not wholly confined to the populous town. Men need not become boors because they are beyond the city limits. Good manners may and should be cultivated in the home, and the small social party should not be despised as an embellishment to the ordinary life of the agricultural section. Laying aside envy and malice, let them seek to exercise a social, sympathetic, friendly spirit, and cultivate the amenities of life. The result will be that they will gradually become ladies and gentlemen in spite of themselves. It need scarcely be said that such a life will always be attractive, even in contrast with the din and uproar of the crowded city. The term "neighbor" will come to have a significance that is suggestive of tender sympathies and kindly offices, so that hallowed memories will cluster around it.

If the sections of country chiefly devoted to agriculture will struggle to maintain a high tone of morality, for which they have many advantages beyond those engaged in other pursuits, they will make the pursuit in which they are engaged so far exceedingly attractive. Honesty, honor, and the other social virtues are brilliant ornaments to any mode of life, and will dignify the most lowly calling. These are within the reach of every man, and when they become characteristic of an entire community they impart a lively vigor to the atmosphere breathed there that will make it attractive to all who experience it. "Men may come and men may go," but such charms will never die out. The cold selfishness, the heartless struggles, of the greater part of mankind, in contrast with this kind of life, will be like the chilling winds blowing around a cottage that shelters a happy family warmed by a blazing fire within. The attractions of one above the other are apparent and real.

An interest in the maintenance of church privileges, on the part of communities that live upon the fruits of the earth, will make their pursuit more agreeable, and give it so much more power to retain those who are engaged in it. Religion sweetens and hallows all the relations of life, till the church where we worship, humble though it be, becomes the centre of an influence that envelops all a man's life. He never forgets, or wishes to



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forget, the strong, unobtrusive force that binds him to the place and the pursuit where he has felt its power. The day of rest becomes to him a day of joy, as well as a day of cessation from busy labor. A certain air of desolation broods over the community where there is no sound of the church-going bell, and it seems as if something were wanting to the social life and to the religious feeling that bodes no good to the future peace and happiness of the neighborhood. When men meet around a common altar, they feel something of a common interest in each others' joy and sorrow, grow up to perceive the obligation to care for each others' welfare, and there is a natural tendency towards a nobler manhood and purer enjoyment. All care for the place of worship, all effort to make the instruction of the pulpit better by encouraging the pastor, tend just so much to make the prevalent pursuit of the people attractive, and thus assist the general prosperity.

The farmer himself must respect his own occupation if he would make it attractive, so as to retain his own children in it and induce others to engage in it. He should not regard it as something to be escaped from as soon as possible, and only to be endured as a calamity. Let him respect his calling, for it is certainly respectable. Let him honor it, for it is certainly honorable. Let him do his best, and he will make his pursuit, if not lucrative, at least remunerative. He is generally the owner in fee simple of the land he cultivates, and sometimes he treads in the footsteps of generations of ancestors who lived as he lives, and dying left honored memories of the deeds they achieved and the reputation they won. Many a dweller in cities owns no foot of the soil nor any shingle of the roof that shelters his head; but the farmer possesses a home, and walks on his own land, tilling his own soil, free from any call for annual or quarterly rent. Through the day he breathes a pure atmosphere, and at night sleeps in peace in his own house. Nature is constantly smiling upon him, as she does not upon many others. Let contentment dwell in his breast and satisfaction be manifest in his words.

If we would make farming in the highest degree attractive, we must endeavor to make practical progress in carrying it on. We are not to settle down as on the stagnant lake of complete

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achievement, but with open eyes and alert footsteps ever seek for something in the way of improvement. The science of agriculture may become a discipline of the mind that is not to be despised as a means of culture. Some new experiment may be made every year in testing the value of soils of different quality, or the advantage of different modes of cultivation. There is a chance for investigation, for the use of careful thought, which involves the exercise of more varied intelligence than some mechanical pursuits. There is variety in the labor of a farmer, which, in the course of a year, amounts to much, and which will present the possibility of improvement, and which ought to test the ingenuity of every man engaged in the pursuit.

Every farmer who has accomplished anything of consequence should not be slow to let his neighbors know what he has done. They may be encouraged, by knowing of what he has done, to go and do likewise; and thus emulation and mutual encouragement will be powers to urge on the sluggish and help the weak, and in the end the whole will advance. The life and energy of the guild of farmers will be an attractive force as against the dead level that nowhere rises towards anything better.

Allusion has been made to the influence of the common school in making farming attractive, but the higher education may exert an influence in this direction. If the farmer has anything like an appropriate conception of the dignity of his occupation, he will not neglect discipline of the mind, of the higher sort, but strive to make his pursuit more attractive through the manifest advantages that a thorough education and finished mental development exhibit in those who follow it as a means of livelihood. The higher grade of schools and academies, the agricultural and scientific schools that cluster around the college of the state, the college itself, all throw open their doors to farmers and to farmers' sons on the same terms as to all others. No man should deem his pursuit a bar to learning, or learning a bar to his pursuit. All pursuits are laborious: every profession has its burdens, that are in some sense obstacles to liberal culture, the pursuit of knowledge on account of a love of knowledge. A strong determination on the part of the toiling husbandman, a disposition to save his time, even the fragments of it, will, with the opportunities that time gives him, demonstrate that he

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is a proficient in more than one kind of labor. If he is diligent and economical in the use of time gained from what he calls the main business of his life, he will find at his control hours that aggregate a sum too great to be wasted. But, like the lawyer, the physician, and the clergyman, he will be obliged to regard something else than free mental culture as the chief pursuit of his life, and he must make a vigorous effort if he is to keep abreast of the intellectual current of the age. If farmers would do what they can for the mind as well as the body, they would increase their own happiness, and add a new and shining attraction to the pursuit of agriculture.

The farmer may increase the attractiveness of his occupation by considering and insisting upon a proper view of its essential relations to the well-being and to the existence of the race as an organized social body. All wealth comes from the earth, and agriculture brings more of that wealth into a form in which it will possess utility than any other single pursuit, and lies more at the foundation of civilized life than any other pursuit. Society in its most primitive shape could not long exist without it. All legitimate pursuits are mutually dependent and mutually helpful, yet this is the one that, more than any one besides, bears the others on its shoulders. It puts the food into the mouths of all; its hands toil for all; and when it ceases to be, all civilization must become rudimentary, or have no existence. Commerce has no reason and no power to exist except as the servant of agriculture and manufactures. Manufactures, by themselves, would be of the rudest sort, and would never be able to give life and strength to the slenderest commercial system. The wheat fields of Russia, of Asia, and of the United States furnish the conditions upon which the mightiest and most complex systems of civilization the world has ever seen live and flourish. Without the cultivation of the earth reduced to a system, developed by science, carried on by the persistent and intelligent labor of multitudes, barbarism would again reign where now smiles an opulent civilization. Its essential relation to all that makes life worth living, if properly insisted upon, will confer attractions upon a pursuit that some are disposed to regard as possessing the least dignity and comeliness of any of the more prominent occupations of mankind, by which they

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amass fortunes, and win reputations that stand in the place of fortunes. The foundation of a building, though it be less attractive for its beauty than some other portions, is more essential than anything else, and by its strength and massiveness is better adapted to command our consideration and respect. It saves the building from collapse and ruin, and often remains when the superstructure has fallen into decay, and has left behind no other trace. The noblest pursuit in which men ever engage may be shorn of all its dignity by the vices and recklessness or indifference of those who follow it.

The pursuit of agriculture presents fewer allurements to an unwise course of life than many other occupations. It furnishes better opportunities for mental culture than most pursuits. It bears fruitful results with more certainty and uniformity than other vocations. The variation in the value of its products is less than that of most other methods of industry. The capital invested in land is likely to remain. An ill-judged mortgage may occasionally sweep it away, but it has more permanence than most other investments. It deserves to be held in a high degree of respect by all who are engaged in it. The structure of human wealth rests upon it, and it will ever be the essential foundation of civilization. Every farmer, who honors and strives to exalt his occupation, is doing so much towards making it attractive and a field for the investment of capital. The more honorable the business, the better the position of all engaged in it, and the greater the self-respect of each one, and sometimes the stronger the tendency towards upright and becoming conduct. Let it be considered an honorable ambition to desire the ownership of a portion of the earth which God has given to the race, commanding the cultivation of it, that from it may flow streams designed to support a teeming population of men, capable of progress and enjoyment in all that exalts and blesses the race.

We love our native state that gave birth to us and others more noble,—heroes, statesmen, patriots, soldiers, orators, and clergymen of pure lives and pious service. Many distinguished men have been in the ranks of the agriculturist. Others shall yet arise to occupy their places. A nation of farmers will be naturally inclined to freedom and self-respect. Law will be regarded

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as the handmaid of justice. Virtue and religion will introduce prosperity, and little will be wanting to the happiness of such a people. America, which we love as we should if our ancestors had been here since the flood, will grow brighter and better. As the pursuit of agriculture becomes attractive and more respected, labor universally will be more respected, not simply as a passport to wealth, but as the state to which God has appointed man, and in which he may win honor and esteem or lose the respect of men, and fail to acquire much good for himself or those most dear to him.

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# THE SWEET PRINCIPLE OF FRUITS AND PLANTS.*

BY DR. JAMES R. NICHOLS, OF HAVERHILL, MASS.

The most interesting phenomenon connected with the growth of fruits and vegetables is the development in their structures of chemical principles which influence in a peculiar manner the sense of taste. A variety of impressions are produced upon the nerves of taste, some of which are agreeable, and others disagreeable, by bringing in contact the juices of certain fruits, roots, grasses, leaves, &c., in their mature and fresh condition. The sense of sweetness is usually agreeable, while the sour and the bitter are of the opposite character.

The term sweet is applied to a class of bodies which are found in fruits, and in a considerable number of vegetable structures, but we do not clearly understand how they are capable of exerting so decided and pleasurable an influence upon the palate, not only of human beings, but upon animals as well. As we walk through our gardens and orchards, and watch the growth of the luxuriant products of the soil, we do not often stop to consider the intricate and wonderful chemical reactions which are unceasingly taking place in everything that springs from the earth upon which we tread. We place the luscious ripened fruits upon our tables, and partake of them with deep sensual gratification, but we do not often consider the origin and nature of the complex agents which render them so acceptable.

The sense of taste is in some respects the most mysterious and wonderful of all the senses. If the sense of touch is, as seems probable, the parent sense, or the primal avenue through

* Read originally before the Massachusetts Horticultural Society.

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which mind was able to assert itself, it must be that taste was the next most necessary sense for man's elevation and protection. All we know about it chemically or physiologically is, that a delicate net-work of nerves ramifies through the tissues of the tongue, and in surrounding or adjacent parts, and that they have the functional duty to perform of conveying to the "central office,"—the brain,—sensations as regards the nature of what is brought in contact. If we examine into the chemical or physical character of these nerves, we do not find that they are in the slightest respect different from the optic or auditory nerves which transmit sensations so absolutely unlike. They are the same in color, structure, and chemical constitution; but how different their office! Nature has fixed limits to our fields of investigation, and however anxiously we may inquire, we cannot take a single step over the boundary line which divides the known from the unknowable. We must content ourselves, therefore, with the act of bringing substances in contact with the little telephonic nerve conductors of the mouth, and permit them to inform the interior man whether they are noxious or innoxious, agreeable or disagreeable, and not ask how the messages are conveyed.

Substances characterized by sweetness are assumed to contain an organic product called sugar; and, as a class, vegetable structures do contain it in some one of its forms. There are, however, a few substances which have a sweet taste not due to sugar. Acetate of lead is an example afforded in the mineral world, and glycerine is a sweet liquid, the base of fatty acid compounds having no sugar. There is a form called *hepatic* sugar, which is a product of the liver, and some of the secretions of the body contain it. It is, however, in the organic world that we find sugar in the vast quantities needed by man, and in the juices of fruits and plants we find its hiding-place.

Before vegetable physiology and chemistry were understood, the belief prevailed that all the characteristic constituents of fruits and plants were in some way hunted from the soil, and conveyed to their resting-places by the sap, which was known to circulate through living vegetable organisms. Although no sugar could be detected in any soil by the most persistent scrutiny, yet it was supposed that sugar, and its associated acid and other

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plant constituents, were present, and ready for transportation by the ascending sap. We are disposed to smile at this error of our fathers, but we should remember that, in accounting for natural phenomena, or seeking for a reason for things, the easiest and shortest path is the one usually followed. This remains true until we are guided by facts learned from accurate observation and experiment, or until science becomes sufficiently robust to act as an unerring guide.

Science, in our epoch, is capable of explaining many of the former mysteries of plant movements and plant production, and we now know the source of the sweet principle of fruits and plants: we know that the soil has no direct agency in supplying sugar to any organic structure.

Sugar is a very remarkable substance, and its investigation opens to view surprises and paradoxes not afforded by any other agent in nature. It is highly complex in its organization, having a high atomic constitution, and yet it is the simplest of all compounds when considered in regard to the nature of the elements of which it is composed.

In studying the sweet principle of plants, we soon discover that they possess the capability of elaborating more than one variety of sugar in their structures, and that there is a curious blending of several forms in the ripened fruits which come upon our tables. We discover, also, that each plant has the power of manufacturing a special variety, or a combination of varieties, and that this law of their constitution cannot be changed by man.

In beet roots, in the stems and trunks of the sugar-maple tree, the sycamore, the palm, in sugar-canes, in the sorghum plant, in the stalks of maize, in grasses, we have one kind of sugar called *sucrose*, which is the sweetest variety; in grapes we have another distinct variety, called *dextrose* or *glucose;* in apples and other fruits we have still another, called *fructose* or *levulose*. In melons we have a sweet which is nearly pure *sucrose*, or cane-sugar. We learn from this examination not only that sugars differ widely, but that, for wise and doubtless beneficent reasons, the Supreme Intelligence has not permitted all fruits and plants to be sweetened alike. In that vegetable monstrosity called a beet, which is hidden from the clear sunlight and air during the whole

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period of its growth, there are found juices which hold the most noble and valuable form of sugar known to man. The crimson tissues of this root contain the snow-white sugar which graces the tea-tables of the kings and princes of continental Europe; and millions of pounds find their way into commerce, always commanding the highest prices. The humble, earthy beet can hold up its head in pride, when its sweetness is contrasted with that of the petted grape, which occupies the foremost place among our delicious fruits. The grape is sweetened with glucose, an ignoble form of sugar which the chemist can make in the laboratory, and its production does not require the employment of costly or rare materials. Even if it lessens our respect for the tempting fruit of the vine, the truth must be told. The chemist can make the sweet juices of the grape from old cotton rags and old newspapers; and if this statement does not indicate a sufficiently low origin, I have only to remark that it can be made from common sawdust as well. Human art has not yet been able to number among its triumphs the production of the sugar of the beet, the maple, or the cane.

The sweet principle of fruits, other than the grape, cannot be imitated in the laboratory. It is a mixture of at least two forms of sugar—*sucrose* and *dextrose*—in varying proportions, as is shown in the tables on page 8.

How curious and mysterious is this plan in nature, of delicately adjusting the taste of our noble fruits so as to produce a sense of the highest enjoyment in their use. In some fruits we find the sweet to exist in its lowest modified form; but this is not due to a lessening of the amount of the sweetest sugar, but to the presence of an entirely different kind. It is probable that the peculiar delicate flavor and taste of the grape could not be secured by any adjustment of quantity of sucrose or cane sugar, or by any mixtures. It requires glucose, pure and simple, to act in conjunction with the delicate acids, in order that we may have this fruit in its highest perfection. The watermelon would not be the fruit it is if it had not the capability of manufacturing cane sugar in large quantities; neither would the apple, the peach, the cherry, the strawberry, and the pear be what they are, if the plants and trees upon which they grow had not the power of bringing into play a subtle chemistry, by which

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is produced a mixture of distinct forms of sweets which no art of man can imitate. If there were in nature but one kind of sugar, the number of choice delicacies in our gardens and fruit orchards would be lamentably small.

But nature does not, in the bestowal of her fruits, spontaneously, or of her own free will, sweeten them for us so acceptably. What are designed to be luxuries, and the most highly prized forms of food, she ordains shall be bestowed only through the exercise of labor, care, and skill on the part of man. No one of the fruits in its wild or native state holds any considerable quantity of sugar of any kind—not enough to make it acceptable to the taste, or fit it to serve as food. It is only by skilful cultivation, by hybridizing, by budding and grafting, that we have secured the sweet principle in fruits. We have, as it were, educated the dumb chemists in the vegetable cell, and fitted them for the work which nature made them competent to perform under man's guidance.

It is indeed wonderful that we can increase or diminish the amount of sugar in any kind of fruit or plant by cultivation. The beet, for example, under ordinary care, will afford from four to six per cent. of sugar; but by scientific and generous culture, the percentage can be nearly or quite doubled. I have succeeded in increasing the sweet principle in apples, grapes, and peaches, by cultivation and proper fertilization, and this, when the principle was originally present in normal quantity. In increasing the sugar we also increase every other desirable quality in the fruit; for one principle cannot be forced into prominence without being accompanied by all the others.

I will now endeavor to explain by the aid of chemical symbols the nature of the different sugars, and also show the nature of the sweet principle of some fruits. In the arrangement of symbols, table No. 1, I bring to view the atomic constitution of a molecule of sucrose or cane sugar; also that of starch, and the necessary changes to convert starch into sugar.

*Table No. 1.*

| | |
|---|---|
| Sucrose . . . . . | $C_{12}$ $H_{22}$ $O_{11}$ |
| Aqua . . . . . | $H_2$ O |

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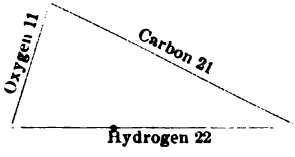
| | |
|---|---|
| Starch . . . . . | $C_6 H_{10} O_5$ |
| Multiply by . . . . . | 2 |
| | $C_{12} H_{20} O_{10}$ |
| Add . . . . . | $H_2 O$ |
| Sucrose . . . . . | $C_{12} H_{22} O_{11}$ |

*Table No. 2.*

| | |
|---|---|
| Glucose . . . . . | $C_6 H_{12} O_6$ |
| Multiply by . . . . . | 2 |
| | $C_{12} H_{24} O_{12}$ |
| Subtract . . . . . | $H_2 O$ |
| Sugar . . . . . | $C_{12} H_{22} O_{11}$ |




Alcohol . . . . . $C_2 H_6 O$

*Table No. 3.*

HOW FRUITS ARE SWEETENED.

| | Cane Sugar. | Grape Sugar. |
|---|---|---|
| Strawberries . . . . | 6.37 | 4.98 |
| Peaches . . . . . | 2.10 | 3.17 |
| Pears . . . . . | .62 | 8.42 |
| Oranges . . . . . | 4.22 | 4.36 |
| Grapes (Black Hamburg) . . | .00 | 17.26 |
| do. (Concord) . . . | .00 | 14.08 |
| do. (Green) . . . | .00 | 1.60 |
| Melons (Water) . . . | 8.17 | .00 |
| do. (Musk) . . . | 9.02 | .00 |

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| | | | |
|---|---|---|---|
| Dextrose . . . . . | $C_6$ | $H_{12}$ | $O_6$ |
| Levulose . . . . . | $C_6$ | $H_{12}$ | $O_6$ |
| Fruit Sugar . . . . . | $C_6$ | $H_{12}$ | $O_6$ |

A molecule of common water is represented thus, $H_2O$, which means that it is composed of two atoms of hydrogen and one of oxygen. Now to form sugar out of starch we must double the molecule, and this we do by multiplying the starch molecule by two; but this does not give us sugar. It is necessary to add a molecule of water, which gives us in the diagram, sugar, as shown by comparing the resultant line of notation with the upper.

In table No. 2 is shown the composition of grape sugar or glucose, and also how it must be modified so as to change it into cane sugar. We must first double the molecule as is shown, and then subtract one molecule of water, and this gives us cane sugar, $C_{12}H_{22}O_{11}$. In the triangle is presented a hypothetical molecule of cane sugar, composed of its constituent atoms—oxygen, hydrogen, and carbon. It is apparent that a substance so constituted must be in a condition of unstable equilibrium, for there is constant tendency to change and form new compounds. Sugar is a substance very easily decomposed, and by the application of heat, a large number of new compounds result. One of these new bodies is alcohol, which is represented by the formula

$$C_2H_6O.$$

An examination of the diagrams will show you how starch is converted into glucose. Starch has the formula as shown,

$$C_6H_{10}O_5.$$

Now if we add to a molecule one molecule of water $H_2O$, we have glucose,

$$C_6H_{12}O_6,$$

and this is all that is necessary to convert the starch of corn or potatoes into the sweet principle of grapes.

We cannot convert starch into cane sugar, because we cannot double the size of the molecule and force into combination one more molecule of water. If we could accomplish this result, all our crystallizable cane sugar would be made in the laboratory,

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and the growth of sugar cane, beets, &c., would cease, as the artificial process would supply sugar at cheaper rates.

We can make grape sugar out of starch, because we have discovered a method of forcing one more molecule of water into combination with it, and this gives us glucose.

Table No. 3 explains how several kinds of fruits are sweetened. The percentage of cane sugar and fruit sugars which enters into strawberries, peaches, pears, etc., is shown. It will be noticed that in grapes no cane sugar is presented; the sweet principle is entirely glucose. Of course fruits vary greatly in the amount of sugar they contain. These examples are presented as the results of analysis made with the view of obtaining general or approximative results. Whilst it is possible to increase the saccharine principle, and also to modify the hydrated malic acid constituent in fruits, it is entirely beyond our power to change the fixed nature of vines, shrubs, and trees by any methods of cultivation or fertilization yet discovered. I know of nothing more wonderful in nature than the persistency with which vegetable structures adhere to their original bent or design. Trees producing sour apples, pears, or peaches, or vines producing astringent grapes, cannot be turned aside from their laboratory work, unless by the introduction of scions, or the employment of the knife in other ways.

We all know that two trees growing side by side, from the same soil, breathing the same air, and precisely alike in external and internal structure, will grow fruit totally dissimilar in chemical constituents and physical appearance. If a young sour apple-tree is cut off low in its trunk, and scions of another kind inserted, it is changed only above the point where they are placed. The chemical reactions below continue true to their original instinct, and if fruit comes from a sprout it is charged with the acid juices of the parent tree.

We thus have the bewildering fact brought before us that sap circulating through one portion of a tree culminates in the production of excess of acid in the fruit; while in another there is found an excess of sugar. It is not unusual to observe a newly set scion bud, blossom, and bear fruit the first year. The apple may weigh ten times as much as the frail scion which held it up and supplied the nutriment necessary for its growth, but the

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little twig transplanted to an alien limb will set up a laboratory of its own, and from the strange juices brought to it will manufacture fruit entirely dissimilar to its companion fruits growing in close proximity. An example of this nature was afforded in my orchard, where, from a scion having a surface for cell action of only nine square inches, a sweet apple was grown weighing seven ounces, and affording from its juices ninety-three grains of fruit sugar.

We have, however, still more wonderful examples of fruit chemistry in apples which in their own structure exhibit sectional differences of composition, one half or one quarter being saccharine, the other portions being extremely acid, and having the sectional lines distinctly drawn. I have seen a basket of this remarkable fruit in which the divisions were in all proportions, but each one unmistakably marked.

I have brought to view these interesting examples of plant chemistry, not with the supposition that they are new to you, but simply to awaken inquiry and stimulate research, that we may, if possible, obtain new light upon some most perplexing problems.

The sap of plants, which is largely water, may have but little agency in influencing those changes which result in the production of the sweet principle in fruits. Cell action, controlled by the actinic solar ray, is unquestionably the source or active agent in the chemical changes which accompany vegetable life. The vast volume of water, which in the form of sap courses through our fruit-trees, cannot, however, be lightly regarded. It brings to the cells the elements and molecules of inorganic material, which enter into the reactions involved in plant chemistry; and it is only through the sap that we can beneficially influence the products of our orchards and vineyards. It is probable that we do not often stop to consider the immense preponderance of water in our fruits, which is shown by analysis.

Several years ago I made analyses of several varieties of apples, with the view of determining their exact food value. Among them were the Tolman's Sweet, Hubbardston, and Baldwin.

The apples selected were in different stages of ripeness, the Hubbardston being more advanced than the others. Very im-

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portant modifications are produced by the chemical changes in apples as they approach the stage of maturity, or the period when they become mellow and ready for the table. The amount of sugar increases, and the hydrated malic acid decreases, or disappears altogether in some fruits. The cell walls of the structure become softened, and readily break down; oxidation begins at any point where imperfection or abrasions in the skin occur. The amount of nutritive material is to some extent increased in ripe apples, and they are much more easily digested and assimilated by men and animals.

The results of the analysis were as follows:

HUBBARDSTONS.

| | |
|---|---|
| Water | 88.57 |
| Albuminoids, pectose gum, and sugar | 11.27 |
| Ash | 0.16 |
| | 100.00 |

TOLMAN'S SWEETS.

| | |
|---|---|
| Water | 83.29 |
| Albuminoids, sugar, pectose gum, etc., | 16.54 |
| Ash | 0.17 |
| | 100.00 |

The unripe Baldwins gave 87 per cent. water, with a less amount of albuminoids and sugar than the others, and considerable free hydrated malic acid. The sugar varied from about 5 per cent. in the Baldwins to 9 per cent. in the Sweets. The total insoluble matters, including skin, seeds, pectine, ash, etc., averaged about 3.25 per cent.

These results show how largely preponderating in apples is the water, which in amount is about 85 per cent. of their weight. Therefore a tree bearing thirty bushels (forty-six pounds to the bushel) holds up in the fruit about *half a ton* of water. The nutritive value of apples is, of course, not in the water, but in the solids—albuminoids, sugar, and gum. In a bushel of Hubbardstons there is about six pounds of soluble nutritive material at the period of ripening; in Tolman's Sweets, about seven pounds; in Baldwins, five pounds; and this material will vary

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to a considerable extent in value. Sugar is a carbonaceous substance, and nutritive in a certain direction. It is mainly useful as fuel, and by oxidation serves to maintain animal warmth. The albuminoids are nitrogenous, and therefore are foods proper; the gum is also a food.

The albuminoids are seldom found above half of one per cent. in any varieties, and this would give us less than four ounces in the bushel; of sugar, we find in a bushel about two and a half pounds in acid fruits, and considerably more in sweet.

The analysis of apples as presented, shows that the amount of nutriment, or absolute food they contain, in proportion to bulk, is small. This research extended over considerable ground, much of which is not pertinent to this discussion. I will simply say, that, as regards apples as food for animals, my practical experience in feeding them confirms the results of analysis. They are of some value, and when fed in connection with meal, serve to give zest to the appetite, and keep animals in health. The riper the apples the better the results; and they should not be fed in a half-frozen state to milch cows, as this course will invariably cut short the milk supply. If they are cooked by boiling, their value is much enhanced, as more perfect digestion results.

In the cultivation of fruits, we should not be misled by the fact that they do not, in themselves, exhaust soils, except in a slight degree. The constituent principles of fruits are to a large extent organic, and therefore derivable from water and the atmosphere. Sugar, the important principle of all fruits, takes nothing from the soil which has money value. The albuminoids, as has been shown, are very sparsely distributed through most of our fruits, and as they hold the nitrogenous element, it is seen that nitrogenous manures are not needed in large quantities in orchards or fruit-gardens. Analysis of the grape shows that in most varieties nitrogen, as supplied in manures, is not necessary. The results of analysis, in the case of all fruits, have been satisfactorily confirmed in my practical experience.

I have never found nitrogenous manures to exert marked specific influence upon any of my fruit crops, and years ago I discontinued their use. Fruit-trees, shrubs, and vines need nitrogen, but the spontaneous supply in soils is fully equal to the compar-



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atively small amounts required. There is one mineral element which may be said to be the pabulum *par excellence* of growing fruits, and that is potash. It is certainly true that we cannot raise perfect and desirable fruits if we withhold this element from the soils of our orchards. When it is considered that we influence growing fruits only through the act of rendering the tree or vine vigorous and healthy, and when we further consider how much potash is required to maintain a normal condition in large fruit-trees, which are constantly under the pruning-saw and knife, we obtain some correct views of the importance of this agent in soils. Both the fruit of the vine, and the vine itself, are great consumers of potash. The same may be said of most of our small or soft fruits.

It is not usually advisable to attempt to reclaim and render productive a worn-out grape border; but if any satisfactory success is attainable, it is only through a plentiful supply of good wood ashes and bone meal.

Twenty years ago I discovered that it was best, in preparing borders for cold grape-houses, to use plenty of wood ashes, and to place the fertilizing materials in successive thin layers, rather than in the usual form of a mixed heap. I have one border prepared in this way which is made up of sixty alternating strata of different fertilizing substances, and they have remained undisturbed for twenty years. The fruit product from this border has been uniformly excellent in quantity and quality, from year to year, and renewal has not been necessary.

My view is, that the subterranean feeders of the vine will follow what may be designated as vegetable instinct in procuring food, going no further for it than is necessary. If we place phosphoric acid, lime, potash, and nitrogenous salts in distinct layers, each resting upon one of good soil, we place our vine roots, as it were, at a table spread with many dishes, and unerring instinct will guide in selecting what is needed to keep the vine and fruit in the best possible condition.

The saccharine qualities of the Black Hamburg and Frontignan varieties are greatly improved by having at hand plentiful supplies of potash; and wood ashes is the best possible source for this alkali. The German chlorides are next to be preferred, but do not, in vineyards, meet the desirable results supplied by ashes.

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The ordinary German kainit, as found in commerce, I class among the poisons in the list of assumed vegetable foods. I have never failed to observe injurious results in the use of these salts on my farm. Common salt is not a manure, and we may as well so decide once for all.

After an experience of nearly a quarter of a century in conducting an experimental farm, I have reached the conclusion that the growth of our fruits and most of our cereal crops is best promoted by the use of a fertilizing mixture, made up of finely-ground fresh bones and good wood ashes. This mixture I arranged and recommended twenty years ago, and I find, after persistent soil experiments extending over many years, that I am using it more freely than ever.

My method of preparing it is, to take six barrels of pure raw bone flour and twelve of good wood ashes, and mix them well together upon a shed floor, adding, during the mixing, twenty buckets of water and one barrel of gypsum or plaster. This mixture may be allowed to stand a few weeks, or it may be used at once if needed. If permitted to stand long, it heats from chemical action, and the freed ammonia is in part fixed as a sulphate by the plaster, but not all of it.

For fruits of every kind I know of no better fertilizing material, and as it supplies every needed element of nutrition, its effects are remarkably persistent and immediate.

But, gentlemen, I must detain you no longer. I cannot think that I have presented anything new or of special value to a company so intelligent and experienced as this. There are old facts and forms of knowledge which it is well to call up for consideration occasionally, as we often find that the good and excellent have been neglected because they are old.

On inquiry, Dr. Nichols added, in further explanation of the chemical composition of sugar, that it is a compound of pure water with carbon—absolutely pure water with the elements of a diamond. It is a very unstable compound: when placed over the flame of a lamp the water escapes, and the carbon is brought to view. A molecule of sugar is like a watch-spring wound up: the struggle between the chemical forces is towards change into lower combinations. A potato is but a mass of starch, and can

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be changed almost entirely into sugar. The change of starch into sugar requires the presence of diastase, which is a starch solvent apparently provided for a specific purpose. Sugar cane a few weeks before it is ripe has no sugar: after it is mature it has no starch,—and the case is the same with most fruits. The production of sugar is not exhaustive to the soil: the refuse from the manufacture of beet sugar returns to the soil all inorganic substances taken from it. In strawberries there are three kinds of sugar, two of which are uncrystallizable and one crystallizable. Most pears contain uncrystallizable sugar. The orange will grow in sand with the addition of potash and lime. The Black Hamburg grape, when ripe, has about seventeen per cent. of glucose, and its juices are most agreeable, though we cannot tell precisely why. Changes in fruits go on with great rapidity at the time of ripening. Beet sugar is as sweet as cane sugar. The chemical composition of milk sugar is the same as that of cane sugar, but it has only one third of its sweetening power. We have in the sugars interesting examples of isomerism,—bodies, so far as we can distinguish, constituted alike chemically, but having very unlike physical properties.

Dr. Nichols also stated that wood ashes are often adulterated. He bought one lot from Canada which contained by analysis nine per cent. of potash, but the next lot had less than four per cent. He regarded the discovery of the Stassfurth potash salts as providential; the supply is enormous, millions of pounds being produced each year. In kainit there is so large a proportion of common salt that it is apt to kill grass. The chlorides of potash may be mixed with phosphates and nitrate of soda, and extended with humus, so as to form composts closely resembling stable manure in concentrated form. The Stassfurth salts are now brought to this country and used by official analysis made at the salt mines, and these determinations are usually safe and reliable.

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# FLOODS CHECKED BY RE-WOODING.

BY S. W. POWELL, IN SCIENCE MONTHLY.

Professor Guyot taught that variety of coast-outline, of elevation, of climate, and natural products, is necessary for the richest development of the individual and of society; and that in no part of the world were so many of these favoring conditions originally brought together as in the regions bordering the Mediterranean.

The Roman empire, which, at the time when it was most widely extended, consisted almost entirely of the countries lying around or near this sea, had the best situation of any of the great empires that have arisen. The grouping and arrangement of the land and water masses; the diversity of elevation and of coast-outline; the rich and varied scenery; the wide range of animal, vegetable, and mineral products; the great number of populous, wealthy, and nobly built cities, with the marvellous Roman roads binding them together, and the majestic Roman law coördinating their civic life,—all coöperated to make this region the garden of the world. The fact that the most favored part of the earth's surface should have been so nearly ruined, as it has been, by selfish and short-sighted treatment of the forest, its most precious possession, ought to have been a lesson to all future settlers of new territory. That it has not been heeded by the settlers of North America, the increasing frequency and severity of floods and droughts, and the swift and menacing approach of timber-famine, plainly prove.

The streams which flow through the valleys that wind back from the sea into the heart of the mountains and hills bordering

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the Mediterranean, would, in their normal condition, be limpid and perennial. But, owing to this short-sighted cutting of timber from steep hill-sides, and to the equally short-sighted overpasturing of the cleared spaces afterward with sheep and goats, most of these streams were, in the upper part of their courses, changed into torrents, whose beds in dry weather are cheerless expanses of sand and gravel.

During heavy rain, or when snow is rapidly melted upon the mountains (and this is especially apt to occur when a warm wind, called the *Fœhn*, coming probably from Sahara, and saturating itself with moisture as it crosses the Mediterranean, strikes the mountains—Guyot said he had known this wind to melt six feet of snow in twenty-four hours), these torrent channels are almost instantly filled with furious, short-lived floods, which often sweep off bridges, buildings, crops, and even animals and human beings, besides tearing up costly roads, and wash away a vast amount of precious soil from mountain-sides where it is sorely needed, and deposit it in rivers and harbors where it is a nuisance, and often a serious peril to navigation.

In their gullying and undermining rage, these torrents tear out stones and large rocks from the hill-sides, grind them up into gravel and even fine sand, and ruin much fertile land upon which they spread this material.

But there is further mischief, which, as being more widely diffused, is less sure to be assigned to the true cause—the stripping steep land of its covering of trees.

1. There is the failure of springs, because water of precipitation, which should have been delayed upon the hill-sides by the roots, sprouts, mosses, fallen leaves, etc., which fill and cover the surface of the ground under a forest, till it could find the underground spring-sources, runs off the bare slopes in a few hours. Dry springs mean parched pastures, small crops, and unprofitable husbandry.

2. The increased cost of buildings, bridges, furniture, and implements of all sorts, which are, in whole or in part, made of wood. A large item in the current expenses of railroads is the outlay for ties, which must be renewed frequently. Wood for fuel or structural uses is a prime necessity of civilized life; and, as it is bulky, its cost increases rapidly with the distance

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it must be carried to reach the consumer. Many countries have no stores of coal or peat, and must have wood or be sorely stinted for fuel;—that stinting is a waste of time, health, and vitality. Floods make the maintenance of roads difficult and costly, and so, of course, increase the expense of whatever must be hauled over them, especially anything so bulky as wood. Further: Scarcity of timber means the cessation of many lucrative industries which use wood for their raw material, and which are especially desirable as affording employment during portions of the year when agriculture or the care of flocks does not call for all of the farmer's time.

3. There is the derangement of climate and rainfall. It is by no means certain that, at least in some situations, more rain will not fall in a year upon a well-wooded than upon a bare region; certainly, what does fall will not evaporate and be carried away by the winds as quickly. Sudden changes of temperature and the resulting violent winds are also less liable to occur where woods abound. A forest is a better barrier against wind than a stone wall of equal height, because it divides its force, and does not stop it all at once, causing eddies and rebounds which may do damage elsewhere.

In these and other ways many provinces of southern France had been (before 1860) for several generations gradually growing poorer. By a misuse of the right of equal common pasturage upon the lands belonging to the communes, the richer proprietors who had large flocks could get the lion's share of the scanty store. To lighten taxes, sheep and goats were admitted from Provence and the Maritime Alps to summer pasturage, as at that season their own country was so dry and parched that they could find no food. Cézanne, in his supplement to the great work of Surell on the "Torrents of the High Alps," says these migratory flocks "obstruct the roads, and are the occasion of all kinds of disorder. They arrive at the pastures famished, and in a few days destroy the sprouting herb, the hope of the entire season. * * * One can follow the trail of the sheep of Provence by the disappearance of all vegetation. They necessarily migrate in flocks of one thousand or twelve hundred, and, after reaching the pastures, retain the habit—which they acquire upon the road—of crowding together

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and struggling for every spear of grass. In the flinty plains of the south they find very scanty fare, and to satisfy hunger are obliged to move stones with their noses and feet, and to dig the soil quite down to the roots of the plants which they devour. Upon the mountains they continue the same destructive habits, and one can understand what must be the effect upon the light soil, scarcely fixed upon the slopes, of such digging and tearing by these millions of animals."

The little ready money which the pasture-fee of these southern sheep brought into the impoverished communal treasuries seemed indispensable, though it was easy to see that it was bad economy to admit them. Such trampling and tearing weakened the turf so that it was every year more easily washed down hill during heavy rain, and when it went, the soil underneath went too. The farther down the mud and water rushed, the deeper and wider were the erosions. Upon the steeper slopes below, which should have been clothed with woods, the ravages were still greater. As like causes were operating in a similar way upon other surfaces in the same basin, after every heavy rain (especially if it fell upon deep snow) the streams suddenly rose thirty, forty, and even sixty feet, and then again, in a few hours, were at their old level.

If a bank overhanging the narrow gorge at the mouth of one of these mountain basins was undermined and fell across the opening, a lake quickly formed behind, until the accumulating pressure burst the barrier, and then woe to the people downstream! In one such *débâcle* the wave was one hundred feet high, and swept down the valley at the rate of fifty feet a second, or thirty-four and one eleventh miles an hour! "At one point the water was seen pushing before it a moving mountain of all kinds of *débris* of three hundred feet in height, from which was rising a thick cloud like the smoke of a conflagration."

Deprived by their own improvidence, or that of their parents, of their forest wealth, the mountaineers thought that they must starve or else use every available acre for pasturage. Planting trees and waiting for them to grow required knowledge and capital, and they had little of either. The damage done by torrents was more severe farther down, although it all began in the uplands, whose turf was loosened by the starved sheep of the

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south. Lack of the timber which should have enriched and protected the zones just below these pastures made the mountaineers feel so poor that they felt constrained to take every sheep and goat which the lowlanders would bring. It was clear that they could not restrict the number of these "summer boarders" and at the same time re-forest the steeper lower zones to the extent which was demanded by their own welfare, and still more by that of the people living farther down-stream.

This made it necessary for the state to step in. Under the feudal system it was held that a seignior, and especially a king, must possess one or more forests. In France, those belonging to the crown have become the property of the state, and for the care of these there have gradually been trained a special class of officers. When the reboisement law of 1860 was passed, many of these were men of great attainments. Surell, born in the Département des Hautes-Alpes, was one of the most eminent among them. As an engineer he had long been familiar with the numerous and costly, and yet inadequate, mechanical expedients which had been tried by the authorities for the purpose of preventing the ravages of torrents. He kept dinning it into their ears that since excessive and unscientific clearings, and unregulated pasturage of the cleared spaces afterward, were the causes of the torrents, so the remedy must be to clothe the steeper zones below the pastures with trees or bushes, and to exclude sheep and goats from the pastures above until they were again covered with a stable turf.

He was not, indeed, the first to protest against the destruction of the woods, and to insist upon their restoration. The famous inventor, engineer, and artist, Bernard Palissy, had discovered the influence of forests upon springs, and raised an unheeded cry to warn men against the calamities which lack of fuel and timber would occasion. The chief nobles, and especially the ecclesiastics, were clearing at a great rate, and taking no thought of those who would come after them. In the time of Henry IV and Louis XIV a sharp check was given to the plundering of the crown forests by these ecclesiastics and court favorites. In 1669, three years after the famous announcement of Louis XIV that he had been long enough in leading-strings, and that he proposed from that time to be master of himself

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and of France, the great ordinance was passed upon which most of the subsequent forest legislation of Europe has been based. Under it, in connection with the crown forests, the science of arboriculture was studied, and a thoroughly organized corps of officials trained.

Before we come to Surell, a passing mention should be made of Fabre and Dugied. Fabre published in 1797 his "Essai sur la Théorie des Torrents et des Rivières," which may be called a prophetic work. It outlines quite distinctly the main principles which were followed in the works of restoration under the reboisement law of 1860. He said sheep and goats must be kept away from young trees, and that no clearing should be permitted except in horizontal strips not more than thirty feet in width where the acclivity of a slope is more than one foot in three, and these strips may be made wider according as the slopes are less steep. No clearings without authorization of competent officials, and on plans made by them.

Dugied, who had been a prefect in the Lower Alps, published a project for re-foresting the Basses-Alps. He said that more than half that department was dry and unproductive soil, and that torrents caused by cutting and grubbing woodland brought *débris*, and added to the barren areas. For remedies, he recommended,—1. Enforcement of the old law of 1667, which imposed a fine of three thousand francs for grubbing steep land; land already grubbed to be turned into artificial meadows. 2. He made careful estimates of the cost of re-foresting the one hundred and fifty thousand hectares in the department which needed it, and recommended that, besides remitting taxes for ten years on re-forested land, and distributing seeds gratis, the state should pay three quarters and the department one quarter of the cost. He showed that the increased revenue from taxes, after the ten years of exemption, would repay the advance in eighty-six years.

Almost every one ridiculed the proposal. It was compared to the "Arabian Nights," and as a reward for making it he was deposed. But at the same time the state was expending one hundred and twenty million francs each year for roads and bridges, and a large part of this outlay—vastly more than re-foresting cost when at last wiser counsels prevailed—was made

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necessary by torrents which every year grew worse, but which re-foresting cured.

Dugied's ideas were, in the main, those finally adopted, except that he left out the essential idea of compulsion. An entire torrent-basin must be taken in hand at the same time, and one uniform process be carried on over the whole of it. As Surell said, success should not be imperilled by the first stupid or stubborn peasant who would not do his part. The state must not only bear the expense, but also assume the direction. Expropriation or confiscation must be resorted to, as is done in taking land for roads, etc.

In May, 1856, when heavy rains fell all over France, floods in the valleys of the Loire and the Rhone did incalculable damage. This so reënforced the appeals which had been made by specialists like Fabre, Dugied, and Surell, that the Corps Législatif consented to make a trial of the new way of fighting floods. The old way, erecting barriers, etc., had been altogether defensive; the new was almost wholly offensive. The method, as an expert expressed it, was "*to drown the torrent in vegetation*," that is, to turf the higher and more level pastures, and then to retard the flow of water down the steeper slopes below the pastures by trees, bushes, fallen leaves, and mosses, so that much of it would have time to soak into the ground and reach the spring-reservoirs, and another large portion be absorbed by the fallen leaves, etc., and held as by a sponge, or be taken up by the growing vegetation; and to hold back the remainder by millions of small obstacles, so that it would reach the stream no faster than a full channel could carry it away; and, finally, that, flowing at no point over bare soil, it might reach the stream-bed as limpid as when it started down hill.

### DIFFICULTIES.

The hindrances to the success of the work were both moral and physical, but the moral were the greater. They were,— 1. The unwillingness of an ignorant peasantry to try any new thing. 2. Reluctance on the part of the Corps Législatif and of local authorities to interfere with private rights as much as the success of the work demanded. 3. The doubt whether such

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torrents would not wash away the plantations as fast as they could be made.

The first two difficulties demanded great patience and kindness in making clear to the peasants the necessities and advantages of re-foresting, and in convincing them that the work would be done so honestly and cheaply that they might reasonably expect to be able to repay the cost of the work and get back their land, which would soon begin to yield some income, and in the course of twenty years would, as a rule, be more profitable than pasture land. A sort of science primer, "Les Études de Maître Pierre sur l'Agriculture et les Forêts," was prepared and circulated among them with excellent results. It consists of eight dialogues between a government teacher and a peasant, Maître Pierre, in which the latter is converted from a stubborn opposition to the reboisement law (which he said would ruin him, because, in obedience to it, his landlord was about to withdraw a certain pasture from his *moutons*) to a quite intelligent advocacy of it. The main reasons for and methods of forest propagation, conservation, cutting, thinning, etc., are gradually instilled into the peasant's not very bright mind. The book is a fine model of Socratic teaching.

The velvet glove was always kept upon the iron hand in carrying out the law. So far as possible the coöperation of those whose land was taken was secured, and none was taken except after full opportunity for every one to learn just what the government meant to do, and to present objections. Local magistrates and land-owners must be united with the state officials upon the boards which decided where to run the lines which included lands to be re-forested.

The third difficulty—doubt as to the possibility of success—was overcome by the prudently bold policy of attacking some of the worst torrents first. Of course, victory over these insured success with less violent ones.

The conflicts with physical obstacles may be classified as preparatory and final. The first thing was to exclude sheep and goats from the pastures above the forest zone. The next was to divide the whole area by horizontal walls into two or more zones, and in the lateral ravines to build as many dams as the case might require, so as to check the downward flow of water,

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and compel deposit of earth above the walls and dams. In the deeper ravines whole trees were thrown with tops down-hill, fascines, etc., being packed among the limbs. Then, with explosives, the sides of the ravines were thrown down upon these trees so as to afford a deep and somewhat level soil that could be planted at once. Horizontal mule-paths about a metre wide were made, where, later on, roads for working the forest would be needed. These paths, in passing ravines, ran upon the dams, etc., and by them laborer and material could reach the points where they were needed in the preliminary works. Besides these paths, there were made, at distances twelve or fourteen feet apart, narrow terraces, supported on their lower edges by pebble walls, and having their upper surfaces slightly sloping in toward the mountain, so that water would be checked, and, as far as possible, made to soak in and find the spring reservoirs.

After all these preliminary works were executed, the final planting began. Generally, the terraces and the more level and deep made-ground in the lateral ravines were stocked from nurseries which were established here and there in the districts to be reclaimed. Where the spaces between the terraces were especially liable to washing, they were covered by thatchings of brush, retained, if necessary, by stones or any convenient rubbish.

In gorges and other places where the danger of erosion and the difficulty of getting out large timber would be greater than elsewhere, the kinds of trees selected were such as shoot readily from the stump, grow rapidly, and can be frequently cut with profit,—in other words, those more especially suited to coppice or sprout-growth culture. A dense coppice resists the pelting of rain, and fixes the soil better than larger trees. The kinds selected for such places were therefore acacias, ashes, elms, maples, willows, alders, poplars, lindens, etc.

By working with a sufficiently large force to cover an entire basin with the various preliminary works, and then to plant promptly and simultaneously, the plantations were not washed away; on the contrary, to use the vivid words of Cézanne,—"These works, so ingenious in their very simplicity, form a network of horizontal lines, like the alleys of a garden. The green

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edgings and linings develop themselves among the innumerable sinuosities of the *combes* [valleys], embracing, from the rocky beds of the torrents to the very summit of the mountain crests, those ravines which were but lately inaccessible, and presented an aspect full of horror. On seeing what has been done, one immediately understands how such a combination should be effectual. Every liquid molecule, so to speak, is seized individually; the thin sheet of water flowing down is retarded in its course by a thousand thirsty little plants, by the lines of cultivated herbage, and by the hedges of shoots and trees. It is compelled to tarry a little on each terrace to slake the thirst of the ground, and when it reaches the lower end of a furrow it spreads itself out on the flattened bed there prepared for it. Stopped at every barrier, it loses its vital force on every hand, and, finally, from resting-place to resting-place, and from descent to descent, it arrives, after a thousand retardations, and still limpid, in the channel which conveys it to the river. The violence of torrents is occasioned by the combination of an infinitude of elements infinitely minute, and the system of extinction consists in extinguishing each of these elements without disregarding one;—it is an accumulation of infinitesimal littles. The secondary ravines are blocked up, their minute ramifications are intercepted, the lesser flanks are filled up, and finally there are spread over the soils, completely to diffuse them, the innumerable threadlets [of water], divided and subdivided like the fibers of a root."

In conclusion, it is gratifying to be able to state that all opposition to the reboisement law is in France a thing of the past. The credits voted for the first ten years were at the rate of only two hundred thousand francs a year. Now nearly twenty times as much is readily obtained by the forest administration. The total annual outlay upon the state forests is about twelve million francs; but the direct revenue derived from them is more than three times that sum, besides the vastly greater incidental advantage of building up the agriculture, commerce, manufactures, health, and general prosperity of the restored regions, to say nothing of the diminished expenditure needed to replace roads, bridges, and other structures formerly destroyed by the torrents. How much longer shall we refuse to heed what

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the experience of other countries teaches with regard to the treatment of forests?

In the recent Ohio floods the states which suffered most—Ohio, Indiana, and Illinois—were not those where most of the de-foresting was done which caused the floods. The Hudson's head-waters are almost all in New York, and it is in the power of her legislature to provide the needed safeguards.

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# THE BASIS OF OUR DOMESTIC ECONOMY.

BY C. C. LORD, OF HOPKINTON.

1. The aim of society to-day implies a higher civilization. The society of New Hampshire is involved in a general ambition. This fact is more apparent as the years increase. We are more and more earnest to become something higher and nobler than we have ever been before.

In this popular expression of ambition the prospects of the home are made of prominent consideration. This is as it should be. The quality of the home anticipates the nature of the general social compact. In the contemplation of the needs of home, one sees the demands of society at large, for true society is only an extension of the domain of home. This fact explains the inevitable ramifying uses that are developed as one prosecutes the improvement of his home. Human nature, in general and in particular, aspires to the fulfilment of universal ends. Our better life is like a mathematical progression. We begin with a simple term, and find ourselves involved in an ever-increasing complement of all the terms. Hence, those who seek to improve our homes and society conceive of a multitude of minor objects to be accomplished, and which make up the classified sum of physical, mental, and moral improvements.

The way to realize a wide range of physical, moral, and mental improvement in New Hampshire is a broad subject of discussion. We can comprehend it only as we apprehend the scientific bases of its prosecution.

2. If a scientific engineer were to consider by what means he could move a heavy body from a lower to a higher point in



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space, he would calculate all the contingencies with mathematical exactness. He would calculate the weight, the resistance, and the amount of propelling force necessary to overcome both. We must proceed in a similar way in anticipating human social progress. We must make an absolutely scientific calculation. Unfortunately, however, our social relations are so involved and complex that we can at present only comprehend them in part. So we must as yet be content with only partial results. Still we must keep struggling upon a true scientific basis, or we shall never really accomplish anything. If we wish to improve ourselves as beings possessed of physical, mental, and moral attributes, we must advance with some certain knowledge of the essential nature of these attributes, and the laws of their being and existence. Though we do not propose to attempt to fathom these matters to their depths, yet we intend to try to anticipate a few points in human science that cannot be overlooked if we desire to take even a few steps of domestic and social progress. We speak thus as a citizen of New Hampshire.

3. In considering social prospects in New Hampshire, we have to observe, first, that man is a physical being. This observation implies more than a universal demand for physical sustenance. It means that a great majority of the people in New Hampshire are compelled to consider constantly the means of physical sustenance. Almost all the people in our state are obliged to work for a living. But this fact is mathematically qualifiable. In its first aspect, to work for a living is to struggle to maintain the integrity of the body at a temperature of 98° Fahrenheit. We may say this is the first item of account in the calculation of domestic and social dynamics. In a sense, this represents the weight that is to be moved, for we cannot advance materially unless the integrity of the body is substantially maintained. Now the direct resistance to the movement of this weight is 51.25° of adverse lower temperature. In other words, Mr. E. D. Couch, of Contoocook, who has kept the daily record of temperature in one spot for twelve years, tells us that in that time the average of temperature in central New Hampshire has been only 46.75° above zero, or only 14.75° above the freezing point. As every rational person can see, the

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normal temperature of the human body being 98°, the measure of temperamental disadvantage in this state is expressed by the measure of 51.25°. Now this record and calculation may be considered an average fact or an approximation to an average fact, but the illustrative truth is the same. This approximate disadvantage of 51.25° of lower temperature cannot be ignored in contemplating the possibilities of local, domestic, and social attainment. To think otherwise were just as irrational as to suppose that a locomotive can draw a train up a grade of over fifty feet to the mile as easily as on a perfectly level plain. But let us see how this affirmed fact operates.

4. Everybody knows that the consumption of fuel is an important item in the exercise of various kinds of mechanical force. The physical dependence of animal life and integrity upon food is analogous to the frequent dependence of mechanical energy upon fuel. The body, to maintain integral force against any special odds, needs extra food, just as a locomotive needs more fuel to draw a train up a steeper grade. In New Hampshire we may scientifically expect that all diligent laborers will demand a liberal supply of food.

A few years ago we were much interested in an incidental remark of the wife of a New Hampshire citizen. Her husband was a well-to-do farmer, able to employ considerable help upon his farm. His wife was relating something of her domestic experience to certain lady friends whose homes were not upon farms. She said in substance this: "You have no idea how much food is required in our house. Farm hands eat enormously. All the fragments of the previous day are consumed at breakfast, dinner takes all the immediate substantial reliance, and we have to go to the store to buy something for supper." This remark was made in a burst of conversational ardor; hence a margin of allowance may be made for the intensity of the statement. But this housewife's testimony is true. Farm laborers in New Hampshire require much food. The same is true of all kinds of laborious manual workers in this state. Energy implies fuel. In our state, food is not simply required to supply force for pulling, pushing, lifting, lowering, and racking to and fro, but it is needed for the support of all these activities in the presence of an annual obstacle represented by 51.25° of

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adverse lower temperature. Let no employer of manual labor in New Hampshire disregard the extended dietetic needs of his help if he anticipates a liberal return for their toil.

5. However, the consideration of the subject of physical sustenance in New Hampshire is suggestive of a still greater contingency. Contemplating the amount of energy required to move forward an individual or social body, we must anticipate hindrances other than mere ponderability, so to speak, and the direct resistance of an opposing force. There are elements of incidental friction that we must take into progressive consideration. The distance of a station of demand from the place of supply is an item that cannot be rationally disregarded. The fact that the soil of New Hampshire is no longer a virgin one suggests a new factor of resistance to our domestic and social growth. Other things equal, life on a new and prolific soil is easier than on an old and partially exhausted one. The amount of dynamic resistance to direct social advancement implied in the present inferior condition of our soil is a difficult thing to compute with mathematical accuracy. If we knew that our soil were just one half as productive as it once was, the fact would not certainly warrant the statement that a New Hampshire living is now just twice as hard as it was at some previous time. The yearly increasing distance of the main source of supplies must be taken into account in every last computation of our vital prospects. When New Hampshire people first began to buy wheat, the state of New York furnished apparently inexhaustible supplies. Now we take our wheat from Minnesota and still more western states and territories. Partly by the indulgence of a pun, the computation of our continued physical chances expresses a kind of geometrical progression of which we cannot yet forecast the last term. But we must grapple with the problem if we are to be a thriving and progressive people. Exemption from the task is ont of the question. It is unnecessary to state that we have ignored it in the past. The presence of numerous forsaken homesteads and uncultivated fields offers sufficient direct testimony upon this point. This testimony of abandonment and neglect runs far back into the ages. Mankind as a whole have been uncalculating. The race has thoughtlessly lived for a time mainly upon the spontaneous

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largesses of nature till the fund became partially or wholly exhausted, and then jogged on for new sites and fields. The active principle of carelessness of material facts leads many a man to grapple with life on New Hampshire soil, struggle a while, grow discouraged, give up, and change his vocation or go west, while he wonders at the mysterious destiny that forestalls his experiences. Fate will seem different to many of us when we learn more of the laws of individual and social dynamics. To speak like a mathematician, human life conforms to the law of coëfficients, exponents, variables, and constants, of which one must have some definite and positive knowledge before he can advance far in the sciences.

6. The discussion of our present theme involves a matter of a still more complex nature. It seems to be a dominant fact that a simple individual power cannot be successfully exerted in more than one direction at once. Applied to human life, this theory is briefly expressed. One thing well done is the fulness of average individual accomplishment. Those hard-working manual laborers, who plague the good housewives by the exceedingly large demands of their appetites, do not occupy much time with intellectual subtleties or æsthetic illusions. They give little attention to the adornment of their bodies or their minds. Respite from labor affords them only a season of rest and recreation. Any man who once gives considerable time to study and laborious manual work understands this fact. Though possibly inclined to intellectual habits, such a one cannot escape the drowsiness and dulness that threaten to overpower him when he turns from bodily to mental work. But the law of this case has a counterpart expression. The specially studious and reflective man sacrifices the ability of diligent and effective application to manual pursuits. A young man once said to us, in effect, "Do n't talk to me of writing farmers, for they always have the shabbiest farms." There was a large measure of prejudice in the young man's tone, but there was also a large measure of truth in his utterance. He who scientifically comprehends and vigorously formulates an intellectual theory does as much work as most men can successfully undertake. Attempting vigorous mental application and thorough accomplishment, a man must have other means of support than the labor

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of his hands, or he will fail in at least one department of his activities. History confirms our statement. The men who have thought out the world's great problems have been exempted to a great extent from the laborious physical exertion required to support a man in New Hampshire. Scientifically speaking, we must not despise the fact that here at home in New Hampshire we are daily dependent upon ideas evolved in a climatic region where the temperature of the atmosphere annually averages from 60° to 80° in the shade. Our best ideas of science, religion, philosophy, law, and politics were conceived centuries ago in Egypt, India, Chaldea, Syria, Greece, and Rome. It is true that the founders and framers of New England society have drawn from the storehouses of ancient semi-tropical thought; and if we were to-day socially compelled to depend upon the ideas that have been originally evolved in a temperature of 46° of annual average, we would find our relapse into barbarism disastrously imminent.

We anticipate that some readers will be inclined to resist this sweeping statement, asking allowance for numerous self-made gifted persons of native birth, who have adorned the society of New England and of New Hampshire. We admit these instances, but we must also regard them as exceptions that do not prove the rule. In the contemplation of these characters, people are apt to overlook three things—their frequent extraordinary physical energy, the often special direction of their active faculties, and their great assimilative mental power. Such persons, in fact, are often agents in collecting and bringing to the notice of the masses those treasures that have long lain in the storehouse of the ages, and they in reality impress us more by their adaptability than by their originality. We further believe that were the local facts subjected to scrutiny, we should find the number of those who have failed to fulfil an honest personal ambition through causes that we have portrayed is many times greater than the boasted company of those noted for their comparatively unaided personal success.

7. We now modify the direction of our thought. We have no disposition to dwell abstractly upon individual or collective discouragements. We have thus far pointed out some of the hindrances to local progress, because their consideration is

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rationally unavoidable. In this we have assumed, as it were, the attitude of a social engineer, who is absolutely incompetent without a knowledge of the impediments, barriers, and obstacles in his path. We propose now to present some of the means of progress in our present circumstances, but in doing so shall not attempt to enter far upon the details of the case. Regarding the import of the caption of this article, we shall attempt to indicate only the "basis" of our improving possibilities.

In New Hampshire we realize at least one condition in common with the rest of the world. Human life in general is moderate in the expression of capabilities and powers. Almost all of us are commonplace people, who must live and die without becoming widely conspicuous through any special gifts of nature we possess. This is a fact of which our individual, domestic, and social culture should take cognizance. The sooner our community learns to recognize the truth that a child born in New Hampshire has a thousand chances of being only an insignificant person to one of becoming conspicuous for greatness, the better for all concerned. Understanding the truth as it is, we shall give more attention to the education and preparation of children and youth for the practical, every-day walks of life. Hopeless ideals will then cease to afflict the minds of the rising generation. New Hampshire being largely an agricultural state, we may assume that its population are mostly farmers or similar manual laborers. The basis of our domestic economy must be a working one, of which soil-culture is a prominent feature.

To be as brief as possible, we may say that successful life in New Hampshire implies in general the economization of our physical and intellectual energies. Giving consideration first to the matter of physical economy, we find ourselves occupied with the problem of fostering our animal heat. The adverse circumstance of 51.25° of annual lower temperature directly suggests this. This element of care is operative both directly and indirectly. Nor are comfortable shelter and clothing the only direct accessories to the proposed end. We must eat largely of heat-producing food. Seeing as we do the disadvantage of an extended space between the consumer and his supply, we must practically entertain all possible means of growing such food at home. Excepting in localities offering special facilities

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for ready marketing, we should grow the least practicable amount of succulent or watery crops, and give prominence to the cereal grains and corn. Grain and corn are specially adapted to the dietetic wants of man in a clime of comparative cold; besides, the non-perishability of these products affords a saving element in the instance of a temporary surplus, whereas fruits and vegetables waste rapidly by decay if they are in excess of the immediate demand. We must also learn and apply all practical means of lightening the leverage of our industrial processes. Instead of employing several strokes of work to accomplish a definite object, we must learn to effect several objects by one stroke. We must also husband our incidental resources. Instead of paying many dollars a ton for a fertilizer, we should pay a few dollars a ton for an absorbent, like sulphate of lime, or plaster of Paris, to retain the domestic fertilizing resources that would go to waste without it. In all departments of cultivation and growth, the saving of physical strength and time must be regarded, but we need not enumerate illustrations in this article.

8. The economization of intellectual energy is a point that needs assertion with greater emphasis. The popular indifference to the matter suggests the necessity. With all our learning we have grossly ignored the practical knowledge of the special instrument of learning, the mind. Because the operations of mentality are occult, we have lost sight of the practically material nature of its functions; yet we have consistent grounds for saving mind and thought, as well as body and action. In the mental as in the material realm, for every stroke of work something wears. The reduction of our wear and tear to the lowest practical limit is a legitimate object of our individual and social aim.

The present domain of argument is partially anticipated by our previous assertions. From what has already been affirmed, we may infer not only the right but the necessity of largely borrowing our ideas. Since as a people we in New Hampshire cannot reasonably expect to develop and illustrate much originality of thought, we may demonstrate prudence by drawing aid from the surplus intellectual resources of others. By means of well-selected books and periodicals, we can have sufficient aid

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in this particular. But here we suddenly approach a logical climax. The limited amount of time the average laboring man can devote to profitable reading is a patent difficulty in our way. We have seen that he who toils manually in an annual average temperature of 46.75 degrees cannot immediately relapse into intellectual activity at every interval of respite from labor. In the brief suspension of physical exertion, the reaction passes beyond the point of mere mental exercise to the domain of dormancy. Witness the farmer who falls to sleep while trying to read his newspaper during a few minutes of time snatched from the manual labor of the day. There are only occasional seasons in the life of the physical laborer when the hours are sufficiently extended to allow complete reacting and readjusting conditions between body and mind to be fulfilled, in which he can peruse the printed page with every appreciable advantage. The direct deduction of a young farmer was comparatively legitimate when he once said in our hearing, "A man with two hundred acres of land upon his hands cannot find time to read;" but his assertion was more emphatic than that of many other manual laborers, who only say, "We have now more books and papers than we can read with profit, and there is no use in buying others."

However, there is a solution of this difficulty: it is by shortening the intellectual processes of the reader. The reading mostly done by manual laborers may be assumed to be for purposes of information. The knowledge of the contents of a printed page can be gained in much less time than is usually given to it. No person finds time more valuable than an editor, and he reads a page of a newspaper, as it were, at a glance. Rapid reading may be acquired by the intelligent of all classes. A laborious and intelligent farmer tells us that he once required a whole evening to peruse a weekly paper of eight pages, but he is now done with it in ten or fifteen minutes, and derives just as much from it as he did before. Let us indulge an illustration of the implied method. It were absurd to assume that any individual is required to read all that is printed. Each reader is supposed to select with reference to his profitable needs and tastes. Selection and perusal should be performed rapidly. A person need not enumerate all the articles exposed for sale in a

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country store in order to determine whether he will make a purchase of groceries or of dry goods; and, seeing an object of special need, he has only to purchase, and advance to the next act of privilege. A similar principle may be applied in reading. With a little practice, a person of ordinary intelligence can, as it were, walk into a book or newspaper, glance around, select and appropriate the items he needs, and pass out, accomplishing the work so rapidly that there will be a greater liability to a scarcity of subjects than of time to consider them. By adopting this process one learns to save both strength and time; and this reflection leads us to the consideration of an incidental point.

9. In New Hampshire, to the average individual habits of observation are more profitable than habits of study. In a word, there is little study in our state to-day. We think that it needs only a cursory inspection of the facts of the case to confirm our statement. The vast majority of those of our residents who attempt intellectual work fall short of much study. Our public teachers and pupils are mainly mere memorizers. The deductions we have already made furnish an explanation of this phenomenon. Critical or analytical thinking is not popularly practicable in our present circumstances and mode of life. The semi-tropical idealist may conjure in the laboratory of his own thoughts. We must work for a living. Yet we may observe, practise, and confirm. This privilege, too, has its popularly unappreciated excellences. A child at four years has often learned to speak our English language fluently: this is observation. A youth pursues Latin several years at school, and learns only a smattering of it: this is study. Yet if the process adopted at school were as natural as that used at home, the results in Latin were more marked. In our latitude, thought must mainly grasp, appropriate, and assimilate existing realities. The children at home and at school, the adults in the house, in the shop, and in the field, must apprehend, illustrate, and elaborate things already in their direct suggestions proven. Nor is such occupation and industry in any sense degrading. It is as ennobling as it were to be able to apply the finishing strokes of the brush to a sublime portrait, or of the chisel to a magnificent statue. In fact, the praises that are often bestowed upon the nations of chilly climes result largely from their success in con-

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firming and establishing the ideals originally developed in a more luxuriant but less solidifying zone.

10. Our theme is scarcely begun, yet we must draw to a close. We will present one more point. It relates to the influence of silent associations.

Not long ago a New Hampshire citizen asked us a somewhat singular question. He told us he had put an expensive monument on his family burial lot; and then inquired, "Do you think the money is wasted?" Our reply was qualified. "If you have erected a genuine work of art," we said, "your money is well spent. If you have set up a sculptured monstrosity, the result is different." Art is an assistant and an educator, though its influence is unspoken. The principle here affirmed operates in every department of our lives. We are silently affected by our surroundings, be they good, bad, or indifferent. An eloquent modern writer tells us that a child brought up from infancy in an atmosphere of books is intelligently affected, though too young to read. This occult qualification of personal selfhood extends deeper, broader, and higher as we grow older. Whoever, in conformity to true taste and judgment, adorns his person, his home, or his social avenues, makes the world better, and is a true economist. However, because the modifying function in this case is often ignorantly wrought, it is not exclusively so. Our æsthetic and moral growth and development expand and advance according to laws of strictly scientific appreciation. In the march of life and improvement it is easy to see the power that works the advantage. We say this because our human nature, even in its crudest aspects, seems to be gifted with elevated instincts, sentiments, and intuitions, but they need the help of judicious formularies to perfect them. A young farmer, in a New Hampshire town-meeting, once expressed a great truth when advocating an improved town policy. He said, in substance, "We all want to see our public institutions and interests elevated, but who can climb a ladder that has no rungs to it?" Our conscious advancement must be by means of visible steps, and the ability to take those steps often depends upon our appreciation of the work of others, perhaps of those born long before us. Here in New Hampshire we must observe the models of individual, domestic, and social conduct that have

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proved of the most effective and lasting benefit to others. By the media afforded by our modern arts, we should look into the ways, means, and methods that have attended the development of the noblest, wisest, and best, in all known ages and climes. Having once ascertained an improving fact, we must try to put it in operation; and if we can individually do no more than keep our eyes on the true symbols of real culture, we can gain much from even such a simple resource.

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# RUSSIAN APPLES.

There are few matters of agricultural interest that have received a more careful and thorough investigation than "Fruits for the cold North," especially that of the Russian apple. So great has been the interest awakened, that all our wide domain north of the forty-fifth degree has afforded more or less space for experiment with "iron-clad" fruit, while men of great practical ability and much scientific study have given time, talent, and money to the work, and gained for themselves great honor by their devotion to the subject. Dr. T. H. Hoskins, of Vermont, has been among the foremost in the good cause, and has accomplished as gratifying results as any man in New England.

The two most prominent gentlemen engaged in the enterprise are Prof. J. L. Budd, of the Iowa Agricultural College, and Mr. Charles Gibb, of Abbottsford, in the Province of Quebec. These men are still pursuing their investigations at home and abroad, by correspondence and by study, and, above all, by personal visitation of those sections of the Russian continent that offered the greatest inducement for their investigations.

From Mr. Gibb's report to the Montreal Horticultural Society for 1882 we make liberal extracts, for the reason that nowhere else can be found so reliable information.

If our people have an inclination to make trial of the Russians, they will be aided in their selection by the descriptions of Mr. Gibb. In this respect the paper copied will be valuable.

### RUSSIAN FRUITS.

It may seem strange that the fruits of Russia are so little known in this country, scarcely known even in Germany; that the fruits of one part of Russia are often but little known in another.

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Our fruits came to us, as it were, by chance. In the days of the old French colony, the peasants of Normandy and Brittany brought with them the seeds, and perhaps the scions, of the apples they loved most in their native land. Later the Englishman introduced his favorite fruits, and the Scotchman his. In time the matter became commercial, and we soon had under trial in Canada and in the Eastern states all the best fruits of the *mild humid* portion of western Europe. That not until 1882 we should have begun to explore our own *like climates* in the old world seems strange indeed!

The fruits of western Europe, and their pure offspring born on this continent, as a rule, are not long-lived upon the Western prairies above latitude 43½°, not a success above 45½° in this province, and that only in exceptionally favorable localities. In eastern Russia we find fruit-growing a profitable industry in climates decidedly more severe than that of the city of Quebec: hence we may expect to increase the area of fruit-culture northward upon this continent very largely.

The uncertainty of these fruit-trees of western Europe in the severer climates had led to large importations by the State Agricultural College at Ames, Iowa. Prof. Budd had gathered there the largest collection of fruits for severe climates which I know to exist, but such was the uncertainty of nomenclature, such the difficulty of getting exact information as to their probable value, that the work of sorting out the best seemed a work of many years. Northern horticulturists were looking with great hope to the Russian fruits. The work could not be allowed to rest. Some one had to go to Russia. Mr. Budd and I went. * * * *

Nomenclature in Russia is hopelessly confused. Different names are given to the same apple in different localities, the same name to different apples growing in adjacent districts. So many names, however formidable they may sound in Russian, mean merely round white, white sweet, white transparent, &c.,—names without individuality. Fortunately a few names have been fixed by commercial demand, and are known by the same names throughout Russia.

One great difficulty in Russian nomenclature arises from the strong family likeness of seedlings of like parentage. A hardy

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race of the apple, seemingly more nearly allied to the wild form than the cultivated apples of western Europe, has been grown for many centuries by seedling production, and has been reproducing itself from seed. Yet this is not strange news to us. Some families of apples, even when surrounded by apples of other types, have a strong tendency to reproduce themselves in their seedlings. The Gilpin, or Little Romanite, Mr. Budd tells me, has been producing seedlings like itself in the West. The Calville family, too, is a striking example. Our Fameuse has a large progeny of strong parental likeness, and many think that two or more distinct varieties are commonly propagated under this name.

In Russia there is no standard of nomenclature, no authority that answers to the American Pomological Society or Downing, yet fruits received from that country must be propagated on this continent, as far as possible, under fixed, unchangeable names. The collections of apples on the farm of the State Agricultural College at Ames, Iowa, already number over 400 varieties, inclusive, no doubt, of many duplicates; additions, too, are being made from different parts of Russia. The collections received a year or two ago embraced most, not all, yet most of the best varieties grown in Russia. We must have, on this continent, one fixed standard of nomenclature, and it would seem best that it should emanate from Ames.

The converting of the Russian names into English needs some thought. We have not the sounds in English to render them exactly. In this matter our aim must be simplicity. We need names our farmers can spell and pronounce, rather than a labored but more accurate rendering of the Russian sound. We have usually fallen in with the spelling in the list published by the Department of Agriculture at Washington, especially where varieties sent out by them have become known. However, the sound "ov" or "off" positively must not be spelled "ou" or "ow," as in Antonouka, Titowka, and for convenience we have used "ov," as in Antonovka, Titovka.

### ON CLIMATES.

The true index to a climate is the flora in its botanic gardens, faulty only from the fact that these gardens are usually situated

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under the sheltering influence of some large town, and therefore not a true record of what might be grown in bleak exposures in the same latitude. The same is true of the meteorological stations. They too often record the temperature and winds of a sheltered city, rather than that of the open country.

We frequently heard of very low temperatures in Russia, which do not seem verified by the government records. Thermometers often differ at very low temperatures, especially when below forty, yet the statements I quote in my report were made by careful observers, usually men on the Forestry staff, and I therefore, with this caution, state the temperatures as given to me.

In this part of Canada we suffer from drought, but not from diminished rain-fall. I must explain this apparent contradiction. England is a land of verdure: the lawns are like velvet, the trees and thatched roofs covered with moss. What a contrast to our dry climate; and yet the annual rain-fall of London is nearly thirteen inches less than that of Montreal. It is from aridity of air and consequent rapid evaporation that we suffer.

In Russia we find fruit cultivated largely in climates where the conditions of extreme cold, dryness of air, and scanty rain-fall are greatly intensified.

In the government of Kasan, above latitude 55°, where the winter temperature is five degrees lower than in the city of Quebec, the rain-fall a good deal less than one half, the evaporation as great, we find apple-growing a great commercial industry, *the* industry, in fact, in twelve peasant villages. This is the coldest profitable orchard region of the world, and the conditions of growth deserve study. The soil upon these exposed bluffs is a fine, comminuted, dusty clay. For retaining moisture, for absorbing it, for holding frost without injury to the roots, there is no better. The dry fall here causes perfect maturity of growth: the thick, fine-textured leaf does not suffer from the dryness of the air. It was Mr. Budd whose microscopic study of the leaves of these climates first showed their peculiar cell structure. Thus we see that the apple-tree of Kasan is a tree thoroughly adapted to the climate it lives in. However, the cold of Kasan seems more uniform than ours. In this province we suffer from the warmth of the sun in late win-

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ter and early spring, warmth followed by sudden cold. This results in "bark-bursting" and "sun-scalding" of the trunk and lower branches. Such injury is rare in eastern and middle Russia, but how much this is owing to climate, how much to the character of their hardy race of trees, I cannot say. In Kasan, too, we find the cherry and the plum grown in fair quantity: that is, nearly all the peasants have some.

In the government of Vladimir, a climate scarcely different from that of Kasan, the cherry is grown in vast quantities and shipped by the car-load—upon what kind of soil I cannot say.

At Simbirsk on the Volga, in latitude 54°, a climate just like Kasan, a degree less cold, and about one inch less rain-fall, we find the pear grown in fair quantity, though only of second-rate quality. These trees, too, are thoroughly adapted to that climate, trees of terminate growth, with very thick, close-textured, dark, glossy foliage, just like the pears of northern China. Simbirsk and Toula seem to be the northern limits of pear-culture east of the Baltic provinces.

At Saratof, on the Volga, in latitude 51°, where the winter temperature is but one degree milder than the city of Quebec, we find very large orchards, one of 12,000 trees: a pear orchard, too, of 500 trees, and most of the varieties in good health. Yet here we were told that the mercury at times became solid. So near is Saratof to the desert steppes, so light the rain-fall, that irrigation is necessary for profitable orcharding.

### VARIETIES OF APPLES.

*Anis.* This is the leading apple of the Volga, the apple-tree most highly prized, most largely grown. To the inquiry, Which are your most profitable varieties? the reply invariably was, Anis,—I think invariably: my notes show no exception, nor do I remember one. Such was the verdict in all the orchards of the different towns and villages between Kasan and Saratof. We first met with it in that curious semi-oriental bazaar, the Nijni Novgorod fair. Here we find the Russian peasant orchardist bringing large quantities of it to the bazaar in bark boxes, usually willow-bark boxes, holding about three bushels.

In the southern part of the government of Kasan, in latitude



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55°, the same latitude as Moscow, but 430 miles to the east of it, in a continental climate, a climate of extremes, and yet 600 miles nearer the north pole than the city of Quebec, there are twelve villages where the peasant proprietors are apple-growers. The chief industry, in fact, is apple-growing. When we were there the little trees were loaded with fruit, yet the thermometer had been down to forty below zero the winter previous. Five years before, during one day, the temperature on these exposed bluffs was 40° Reaumur, or 58° below zero by Fahrenheit's thermometer. These low temperatures, however, do not seem verified by the meteorological records in the city of Kasan. Hearing of these low temperatures, I looked for winter injury to the trees, but did not find any traces of it.

In answer to the query, Which is the hardiest apple-tree you have,—the tree that has stood best the most trying winters? the answer, I believe, always was, Anis. The general idea there is, that it is, of all kinds known, the apple-tree that can be grown the farthest north, except what they call the Chinese apple, or, as we would say, the Siberian crab, and these crabs, which are not common, are true Siberian prunifolias, and not less hardy hybrids. In these villages the apple is grown, in a good season, certainly to the value of $50,000. In this, the coldest profitable orchard region in the world, the Anis is noted as their hardiest tree.

Many species of trees become dwarfed towards the northern limit of their growth. The most northern pines and spruces, birches and poplars, are but little shrubs: in the same way we find this Anis in Kasan, especially when growing on thin soil and without cultivation, loaded with fine fruit, and this, evidently, not one of their first crops, and yet the trees not more than six feet high. We find little trees planted two, three, and even four, together in a clump, like stalks of corn, three or four to a hill, and these clumps ten feet apart each way. This is strictly true of some orchards; not so of others, for upon richer and moister soil the trees grew somewhat larger, and as we went southwards, at each town we stayed at we found the Anis larger, until at Saratof we saw Anis thirty-five years planted which had attained a diameter of trunk of ten inches. In nursery it is a slow and crooked grower, such as nurserymen hate to

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grow, and hate to sell after they have grown them; in orchard, a slow grower. Trees in different places, pointed out as thirty years planted, seemed very small. In old orchards at Khvalinsk and elsewhere it was considered the most long-lived tree. We saw there trees seventy years old, at the very least. These were fourteen inches in diameter of trunk, branched low, as the Anis usually is, and, though some large limbs had been removed some years ago, yet the trees were sound in trunk and top.

The Volga is a very old apple-growing region. I am told that old poems, written about the time when Rurik was upon the throne of Kiev, about 850, allude to this. The maiden whose neck was like a swan, and whose lips were like cherries, had cheeks like a Volga apple. The high color of the apples of this dry region is very striking.

A wild, rugged race of apple-trees has been grown here for many centuries from seedling production, until we have a number of seedlings much alike in tree and fruit; and hence it is that the name Anis is but a family name.

As we used to gallop past these peasant orchards in our Tarantass, a basket on wheels without springs, usually drawn by three horses abreast, we were always struck by the beauty, even when some distance off, of one variety of the Anis. This is the Anis Alui, or Pink Anis, and, I suppose, the same as the Anis Rosovoi, or Rose Anis, spoken of at Simbirsk and other places on the Volga. It is an oblate apple, of full, medium size, or about the size of the Fameuse, the color of our Decarie, mostly a deep pink, with a light blue bloom. In these dry climates we may expect high color. When we were on the Volga it was too early to taste it in good condition; and besides this, it is often picked too early, perhaps, to reach distant markets by a certain time. Whether it will color and ripen on its way to market, like a Duchess, or whether, like our St. Lawrence, it will almost cease to mature after it is picked from the tree, I cannot say. The grain is fine, the flesh white and firm. It is really a dessert apple of fine quality. It often sells at two roubles per pood, that is, one dollar per thirty-six pounds, when poorer fruit is selling at thirty cents; and under Russian care it keeps till late winter or spring.

On account of its beauty, and hence its salableness, this Pink

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Anis is the most valuable of the family, and therefore when importing, let us be sure to get it. It would seem to be the Anis of Mr. Shroeder, at Petrovskoe, but would appear not to be the Anis Alui of Kasan, of Dr. Regel, which is described as acid, and valuable only for cooking, unless this is Dr. Regel's verdict of its quality when grown in the cooler and moister summer of St. Petersburg. There are other varieties of the Anis which differ but little in tree, yet differ more widely in texture of flesh, but they are not so pretty.

*Anisovka.* Under this name Mr. Shroeder tells us of a medium-sized, flat, yellowish-green apple, with bright red side, grown a good deal about Moscow, and said to be a very good dessert fruit, that keeps a long time, in fact all winter. Farther south it would not keep so long. Mr. Goegginger, at Riga, gives us a minute description of it, evidently the same apple, which he says is grown a good deal at Moscow, and to the south, and which proves hardy in these severe climates. However, he states its season to be from November to December. Its value to us would depend much upon its keeping qualities. The Anisovka, so named on the Volga, near Kasan, is a sweet apple: that at Orel, Voronesh, &c., was thought to be the same as Anis, or same as Vosnikovka, a small, yellow, sweet apple, said to be grown there in quantity. Such is the uncertain state of nomenclature.

*Antonovka.* This is the leading apple of the Russian steppes, the king apple of that vast prairie region from Tula to the south of Kharkof, from Kozlof to Kiev, a vast prairie region unsurpassed in fertility by any region on this continent. It is the leading apple over a larger section of country than any other in Europe—than any other apple I know of. No apple holds so high a rank above others in any large section of this continent; and yet if the Baldwin were equally hardy, I would much prefer it.

We first meet with it in the cold climate of Tenki, in Kasan, where it is looked upon as the best of the "introduced" apple-trees, and certainly the young trees we saw there were quite promising. In all the towns on the Volga we find the Antonovka noted as hardy as far as tried, and in some places tried long enough to be thoroughly relied upon.

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It is, however, in central Russia that we find the Antonovka so highly prized. In the cold climate of Toula, in latitude 54°, about 120 miles south of Moscow, yet 480 miles farther to the north than the city of Quebec, we find it considered their hardiest and most productive apple-tree. A young tree, twelve years planted, is pointed out as having produced its eight poods, and old trees, long past their prime, twenty-five poods. In one peasant orchard we find the few scattered survivors of a previous orchard: nearly all of these were Antonovka. Strange that this had stood, while other kinds alongside of it, intermingled with it, had been killed—killed by a cold winter, I think in 1867.

In the government of Tambof, half way between Moscow and Saratof, there was a large orchard of 2,700 trees, only 730 of which survived the winter of 1867, when mild, warm, rainy weather was followed by sudden cold. Antonovka, though injured, was not killed: it and Anis stood the best. That winter, at Orel, in February, the thermometer went down to 35° Rea, that is, 46° Fahrenheit, and in exposed places, 37° Rea, or 51° Fahrenheit; and yet Antonovka there is, above all others, their leading apple, and the old trees we saw there were, as far as I can remember, in fine health.

At Voronesh we hear the same opinion, and hear of trees that have produced 27 poods, or 972 pounds, nearly half a ton, and are told that although "other apples have their faults, this has none." It has its faults, but I quote this to show the widely-spread opinion of those who grow it.

At Kursk we still find it their leading market fruit, and on the Bogdanoff estates find it being planted in quantity, as about the best investment the proprietors know of. Such investments scatter broadcast innumerable little dividends in the form of food and labor. What a blessing to a country is a horticultural aristocracy! It begets a horticultural peasantry, a home-loving, peace-loving, law-abiding peasantry. In horticulture we find the safest anchorage for a peasant population. We asked, at the Bogdanoff estates, why they specially chose Antonovka and were planting it so largely, and were told it was because it was always a cash article, wanted in quantity for the northern market, for confections, for drying, for bottling in water, &c., and

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a tree in good soil, and in good seasons, can produce its twenty-five poods.

At the forestry convention, in Moscow, Mr. Budd asked one of the members, who was from Kiev, what were their best commercial apples. He called three others, also from the government of Kiev, and, after consulting together, named Antonovka first. The second upon the list was the Winter Citronen Apfel, a German apple of good quality, but not hardy farther north.

At Warsaw, where the climate is a cold north German rather than a steppe climate, we find the Antonovka one of their leading apples, but not their best, and there not a late keeper. Throughout this vast steppe region the Antonovka is *the* commercial apple, noted for its average annual bearing, its hardiness in extreme climate, its length of life, and fruitfulness in old age in these climates. It is also a first-rate nursery tree, a good straight grower. In nurseries, when we found a number of rows of straight-growing, healthy trees, all of the same kind, it was sure to be Antonovka. Hence it has "a nursery run," just as the Ben Davis had in Wisconsin a few years ago, and likely thus to be overrated; but in central Russia it has been a century on trial, perhaps several centuries, and the quantities of it to be found in the Russian nurseries are grown to meet a known demand. It is a prairie apple suited to rich prairie soils, it would seem. It does well on clayey soils, and likes moisture. On dry, sandy soil the fruit is said to fall from the tree, and to be small in size. The fruit is large, sometimes very large, yellowish, oblong, somewhat conic, acid or sub-acid, with slight sweetness, rather coarse in texture. When left upon the tree till fully ripe, it is said to have a fine melon flavor, but then it ceases to be a long keeper. In quality it is not quite like any apple I know. It may certainly be rated as second quality for eating, and I hope first for cooking. But few of the best commercial apples of this continent are of first quality as dessert apples. Its great fault is its color, though this does not prevent its being in active demand in all the Russian markets: it is the color to show bruises, yet it has the name of being a good shipping apple. At Warsaw it rarely keeps past Christmas; at Moscow, Mr. Shroeder cautiously says, till January or February; in central Russia, it was often said, till March, and I

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think even April was mentioned. I doubt if it will prove a much better keeper than our Fameuse.

How long an apple keeps depends very largely upon how it is kept. The Russians handle their fruit, pack it, and keep it with more care than we do. They seem to look upon an apple as a living thing, to be kept alive as long as possible. If allowed to ripen on the tree it has a rich melon flavor, but then it will not keep. All apples in Russia picked for a distant market are picked rather earlier than we should pick them. When we arrived at Saratof, on September 11, the apples were all picked and shipped to Moscow. At Tula, on September 18, Antonovka was in huge piles in the orchards, five feet wide, covered with basswood-bark matting. At Orel we find what has not been shipped in an open shed in layers, with straw between them.

This tree, on account of its good name and its good growth in nursery, is sure to become largely planted in this country. Its success will depend partly upon its suitability to our soil, but and mainly, perhaps, to the length of time it keeps under our method of picking, packing, and shipping.

*Aport.* This is the family of which our Alexander is a member,—a large and widely-scattered family, and often of strong family type. No accurate notes seem to have been taken of the places where they live and thrive. We cannot, in this country, expect to do such work. The most we can do is to find out what is good there, and import and propagate it here.

It is named Aport, because imported long ago from Oporto in Portugal, just as another Russian apple which long ago found its way into Virginia comes back to Russia *via* Germany, under the name of Virginischer Rother.

Mr. Shroeder describes Aport as a very large, flat, conic apple with a red side, of aromatic flavor, not productive, and too heavy, and liable to be blown from the tree, yet grown a good deal to the south of Moscow, at Orel, Tula, &c.—the best of the Aports. This, I suppose, is our Alexander, but I cannot be certain.

The Aport Ossemie, or Winter Aport, Mr. Fischer, at Voronesh, says, is like Titovka; in fact, often difficult to tell apart, although the one is a summer and the other a winter fruit.

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This seems like the apple we saw under this name on the Volga at Tenki, at Prince Gagarine's, and very like the colored print of the Aport Ossemie given by Dr. Regel. It is a large, oblong, handsome winter apple. It and what we saw in Kozlof market I should think the most valuable of the apples known there as Aport. Of the summer Aports I seem to know nothing. On the Volga we saw several kinds, always large, usually well-colored, and of fair quality, but none that specially struck me as of special value to us. I do not know that they have any just right to the name Aport, yet that name seems to be thought applicable to large apples.

*Arabka (Arabskoe).* Under this name there are one or more apples of decided promise. At Moscow Mr. Shroeder tells us of a large conic apple of very deep color, which is a long keeper. The tree he finds a little tender at Moscow, but says that it is grown a good deal in central Russia. In the market at Kozlof we find what would appear to be this apple in fair quantity, and known as Arabka, and specimens taken to Voronesh were recognized by Mr. Fischer, director of the Botanic Gardens, who considers it a valuable cooking-apple, that keeps till May; but he added, that that which he had received from Riga under that name had proved to be Gros Mogul. At Volsk, on the Volga, in latitude 52°, we found, in an orchard, about twelve trees in profuse bearing, of an apple known there as Tchougounka, which means cast-iron. The fruit was roundish, of a dark purplish red, covered with a light bloom, much like the Blue Pearmain. It was above medium in size, although the trees were so overloaded,—a firm, solid, acid fruit, said there to keep two years. It also has the merit of holding on to the tree so firmly that I could hardly find a windfall. It and Steklianka were the only varieties in this orchard not yet picked on September 8. At Saratof, on the Volga, we visited an orchard of 12,000 trees, where, a week or two before, they were employing 300 pickers and 85 packers to ship to Moscow 25,000 poods of apples. In a good year they either did, or could (I am not sure that I understood correctly), produce 85,000 poods, which is equal to 1,530 tons. From our description of the Tchougounka at Volsk they supposed it to be the Arabskoe, which apple they thought highly of, and placed upon their list as *third* for profit. This

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Arabskoe has been long known at Saratof. The query is, whether the trees I have spoken of as growing at Volsk and Saratof are the same as the Arabka of Kozlof and of Mr. Shroeder: if so, the Arabka is likely to prove a valuable late keeper. A specimen picked at Volsk on September 8 was eaten by us at Warsaw on October 4, a crude, juicy, sharp acid. It had been carried for nearly four weeks in a leather bag, which was usually full of books and apples,—a bag which had its full share of rough usage except when used for my pillow, and yet this apple had received no injury. This Volsk Arabska is really a remarkable keeper.

*Beresinskoe.* Mr. Shroeder speaks of this as a large, whitish apple, with yellow side, flesh firm but breaking, not able to bear carriage well, but a very fine autumn dessert fruit.

*Beriosovka.* This we met and took a great fancy to in the Kozlof market. As we saw it there it was a fruit of full medium size, oblate, red on one side in splashes and specks; very firm, yet breaking, very juicy, with a fine mingling of sub-acid and sweetness. The seeds were black on September 13, yet it seemed likely to keep two months. At Voronesh we showed a specimen to Mr. Fischer, who pronounced it true to name, and moreover said it was a good, hardy, and productive tree, and a fine fruit. Season, late autumn.

*Blackwood (Tchernoe Derevo)* is a tree long known upon the Volga. At Khvalinsk we saw trees of it at least 70 years old, and at Kasan trees 30 years of age. It is a heavy bearer, but not a tree of extra hardiness. It does not sun-scald, but its upper branches are sometimes killed, and this, no doubt, sometimes owing to exhaustion from heavy bearing. On the Volga it is the favorite late-keeping apple for home use. Were the tree hardy enough to be grown at Quebec, it probably would prove valuable as a long keeper.

*Bogdanoff.* This is an apple which has been grown upon the Bogdanoff estates near Kursk, probably for two centuries. Hitherto it has been known under the name of Pipka. There were about 300 trees of it in the orchard we visited. It is a stout, upright grower. Taking an average of years, the Antonovka produces more fruit per tree, but it does not keep so long. A large number of varieties have been tried, yet, next to

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Antonovka, they consider it their most profitable winter apple. As a late-keeping apple for home use, they much prefer it to any other. The fruit is large, and in form, size, and striping much like our St. Lawrence.

The flesh, when tasted on September 21, was whitish, firm, juicy, crude, unripe, rather fine-grained, a mixture of sweet and crude sharp acid. As a long-keeping apple of fine quality, I have every hope of this being a very valuable variety.

A good, late-keeping apple would be a perfect God-send to our province and its like climates. Bogdanoff is a most promising variety, well worthy of its name, which means God-given.

*Bohemian Girl (Tsiganka, Zuiganka).* We saw this beautiful apple in the Voronesh market, a medium sized, semi-oblate fruit, blushed all over with deep pink. The flesh is white, but quite past season when we tasted it. It is a great beauty, and, Mr. Fischer says, a hardy tree; a summer apple well worthy of trial.

*Borovinka (Borovitski)* must be looked upon as a family name. It was a member of this family that long ago migrated to this country, and became known everywhere as the Duchess of Oldenburg. This apple we did not see in Russia. At Tenki, in the government of Kasan, in a peasant orchard, we saw trees in full bearing of a fruit which both Mr. Budd and I, looking carefully at it, thought to be Duchess, but, on tasting it, we found it so fine in grain and so mildly acid that we felt that no such difference in texture and flavor could result from change of soil and climate. At Prince Gagarine's, Borovinka, perhaps this one, is looked upon as one of the varieties long known, not, like Arabka and Antonovka, introduced of late years. In another village near there, we found another apple just like Duchess, but sweet, or, to say the least, sweetish.

Mr. Shroeder, at Petrovskoe, describes the Borovinka as a large, round, pretty, striped apple, good for dessert or cooking, and says it is grown a good deal in middle Russia. We did not see the Duchess there, or any apple like it. We find apples grown at Tula, Orel, Voronesh, &c., called Borovinka, which are not of Duchess type at all,—more like White Koroshavka. At Orel, however, we find a Borovinka somewhat like Duchess, acid, and in season till December or January, and said to be

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valuable and grown there in some quantity, so say my notes, though the apple has gone out of mind. On the Volga is grown a flat, autumn, striped apple, which finds its way in quantity into the Kasan and Nijni markets, also called Borovinka—an apple, I think, worthy of being introduced.

*Charlamovskoe.* Mr. Shroeder speaks of this as a large, flat cooking apple, with a red side, a variety he thinks highly of. Whether this may be that grown by Mr. Webster in Vermont, and described in the Montreal Horticultural Report, I cannot say.

Mr. A. G. Tuttle, of Baraboo, Wisconsin, has an apple received by him under this name, which, Mr. Tuttle says, "has the beauty of Duchess and quality of Domine, and keeps through winter." Mr. Tuttle, I believe, has got hold of a valuable fruit.

*Crimean Apple (Krimskoe).* This is the name under which we find, in different places, apples believed to have been brought from that region.

On the Bogdanoff estates, near Kursk, we find an oblong, egg-shaped, red apple, below medium in size, firm in flesh, and sharp acid mingled with sweet. The tree is pretty hardy there, and, if I remember rightly, the fruit is a long keeper. At Volsk the Krimskoe, though good in color, keeping, and quality, was too small and conic to be valuable. At Kluchiche, near Kasan, at Marquise Paulucci's, we saw a large, roundish, striped apple, something like Duchess, not ripe. The tree was said to be fairly hardy in that extreme climate, and, farther south, noted for its immense fruit.

*Good Peasant (Dobryi Krestianin).* This apple is highly prized by the Russian people, and sells well in their market in spite of its unattractive color and small size. Our Pomme Grise, though long valued for its fine quality, does not sell at extra prices in the Montreal market, and I fear this Good Peasant would fetch but small prices when placed alongside better looking fruit. The tree, both in leaf and bud, is crab-like. Its leaf is prunifolia in form, yet slightly pubescent. Near Kasan we saw trees of it more than thirty years old. At Volsk, Khvalinsk, Tula, Voronesh, almost everywhere we went, either on the Volga or in middle Russia, we found it a great favorite.

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People seemed to go into ecstacies over its delicious flavor. Mr. Shroeder, at Petrovskoe, does not find it quite hardy, though at Tula, 120 miles farther south, we saw a few fine old trees of it. Let us look upon it as a crab—a large-sized green crab, of fine quality—for it certainly is as hardy as some of our hybrid Siberians, and I think we shall find it a useful crab for home use for rather severe climates.

*Grand Mother (Baboushkino)* is described by Mr. Shroeder as a beautiful bright red, medium-sized, oblate apple, of fine quality. At Voronesh Mr. Fischer says it is a good and productive tree, and an excellent, large-sized apple, that keeps till March. Mr. Regel describes it as an apple of first quality, that keeps till May. What we saw under this name were above medium size, flat, rather, with a large, thick stalk; flesh white, firm, breaking, juicy, fine-grained, unripe, but showing every sign of fine quality, and of being a long keeper. Its appearance is against it, yet these hardy long-keepers deserve thorough trial.

*Grushevka*, or pear apple-tree is probably so called from its pear-like, pyramidal form of tree. It is spoken of by Mr. Shroeder as a hardy and productive tree, planted a good deal for market in central Russia, and bearing a small, early, white fruit. On the Bogdanoff estates we see trees of it, with their pubescent leaves of prunifolia form, like the Good Peasant. Here it is spoken of as their earliest apple, white, sweet, of medium size and good quality. At Tula, we are told, it is their earliest apple,—evidently, from all we hear, rather a favorite. The German Grushevka, Mr. Shroeder says, is much like it, but a little better in quality, and a week later. That called Grushevka at Kasan was a hard, yellow, fall fruit. Neither must we confound it with the Gusevka of Regel, which is described as a large, winter, cooking apple, but it is without doubt the Grushevka Moskovka of Dr. Regel.

*Kalamas.* Under this name we saw, in one of the peasant villages in the government of Kasan, an apple of medium or large size, deep red, with a light bloom, the beautiful color of the Pink Anis, but larger, and marked with little dots. The flesh was greenish-white, crude, and unripe. Such a beautiful fruit, thriving in so cold a climate, should not be lost sight of.

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*Koritschnovoie Ananasnoe* (literally the Cinnamon Pine-apple). This, Mr. Fischer says, is a small, flat fruit, of dark brownish-red color, and very fine flavor. The tree, too, has proved very hardy at Voronesh. Mr. Shroeder speaks of its hardiness, its earliness, and aromatic flavor. At Orel, too, we hear it well spoken of,—a fine-flavored early apple, it would seem. The Kor. Anan. of Regel seems very different.

*Koritschnovoie Polasatoe.* This is the tree that stood the extreme cold in 1877 at Petrovskoe, when the thermometer went down to 44° below zero. Mr. Shroeder says that it is much like Ananasnoe, but striped, and ripens a month later, and keeps longer. This apple we saw to some extent in central Russia. In the markets, when piled in pyramidal form, stalks upward, they looked like small Duchess. However, the basin is more shallow, the form more conic. It has a peculiar flavor, and is quite good; a fall fruit which has proved quite profitable in cold climates.

*Lead Apple (Svinsovka)*, Mr. Shroeder says, is a small, hard, green cooking apple, that keeps till the New Year, or till new apples, I am not sure which. We hear of it at Orel and at Voronesh, and, as Mr. Fischer says, it is much like Zelonka.

*Malite (Malt).* This name has been given to a number of apples on the Volga, grown in quantity from Kasan to Saratof. In the government of Kasan a little red Malite is one of their favorite market apples. It is medium or small in size, flat, and often ribbed. The flesh is white, crisp, tender, and juicy. Many of the peasants in the villages near Kasan place it among their five best for profit, and grow it in quantity. At Simbirsk a Malite has the same bright, dark color, but with a bloom like Pink Anis, and yellowish flesh; a fine-grained, juicy apple, with firm but break flesh, and sprightly flavor. At Saratof, Malite, I know not what kind, is named among their few best apples, and is one of the kinds grown there for a very long time. We find other apples, too, more or less of this type. At Simbirsk we find a large fall fruit, somewhat resembling Duchess, and of good quality, quite unlike other apples named Malite, and perhaps worthy of trial.

*Red Koroshavka (Korovshavka Alui)* is one of those strikingly beautiful apples one cannot forget. It has the color of

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our Victoria, a bright deep pink, and any part not so colored is as nearly as possible pure white. It is usually of medium size, often above, regular in outline, and never ribbed like Pink Anis. Like Victoria, its flesh is a pure white, and on August 29, firm, crude acid, not ripe enough to fairly judge. This tree, like the Anis, when grown in the North, is dwarf in habit, and where broken down by weight of snow, sound at the heart, and evidently a young and abundant bearer. At Tenki it was said to keep till January.

*Reinette Kurski.* Mr. Shroeder describes this as a medium-sized, flat, irregular, ribbed, yellow apple, named from the town of Kursk. Not hardy at Moscow, but a good tree further south, and a really good dessert fruit that keeps till spring. The query to my mind is, whether this may not be the Reinette Russki which we saw at Kursk, but which they would not admit to be the Reinette Kurski. It is a five-sided apple, of the size of our Fameuse, with red on one side; a fruit of fine quality, apparently a keeper, and perhaps valuable.

*Roshdestrenskoe.* I can only quote Mr. Shroeder's opinion that it is a medium-sized or largish apple, of high, conic form, much like a Gilliflower; a dark, dull green, with a dark red side. A good table and cooking-apple, and a pretty good keeper. The tree is not hardy at Moscow, but does well farther south.

*Romnenskoe*, named from the town of Romna. This, Mr. Shroeder says, is a round, solid, olive-green fruit, with dark red side. Not hardy at Moscow, but valuable farther south. It is pretty enough to sell, and is a fair dessert and good cooking-apple, that keeps till spring.

*Serinkia (Sierianka).* This is said to be the Lehmapfel (or grey apple) of Germany, and is a very popular apple in the Baltic provinces, where it has been grown, some say, for a century or two. In Livonia, Courland, and Poland, it has been planted in large quantity, and evidently is a favorite fruit. It has been propagated in quantity by the nurseries in Riga. It is a stout, straight, and moderately vigorous grower. The fruit is of medium size, yellow with a little red, and is said by every one to be of excellent quality. Unfortunately we did not see the fruit. In middle Russia too, at Orel and Voronesh, we

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hear it spoken of as a good, hardy tree, and an excellent dessert fruit.

*Skruisapfel.* Dr. Regel speaks of this as an excellent table apple, that keeps until the following summer, and says that the tree endures the coldest winters at St. Petersburg, and has been grown at Moscow, Tula, &c. Mr. Shroeder says it is a medium or small-sized apple, striped (but perhaps this only on one side, I am not sure), a very hardy tree; an apple of really good quality, good for dessert and cooking, that keeps sometimes till August. The tree has branches like a Scott's Winter, which cannot easily be torn out; the fruit, as we saw it, green, with a little dull red beginning to appear on one side, and very heavy. Flesh greenish, juicy, rather tender, crude, and but very mildly acid when ripe—lacking acid, one would think—otherwise quite good. A good late keeper for cold climates.

*Skrute (Beel Skrute)* is a profitable apple on the upper Volga; a good-sized white apple, with red marblings, showy and very popular, but so variable in quality that I have thought there must be more than one apple in the markets under this name. Often its cavity is very shallow, and the stem like a peg that has been driven in; but this is not always so. Though fine-grained and juicy, it is sometimes woolly and flavorless, so that I cannot recommend it, in spite of its wide popularity in those cold climates.

*Sklianka (Steklanka Zelonka).* In this family there are some apples of the Rhode Island Greening type, which promise to be very valuable.

The Zelonka Moldavka of Voronesh is an apple I wish to draw special attention to. The specimen we had was large and oblong, a solid apple, with a texture somewhat like a Rhode Island Greening, firm, acid, with very little sweetness. We got it at Voronesh on September 13, and this description was made when tasted at Warsaw, on October 4. It had been kept in our apple bag, but had not suffered. Mr. Fischer showed us trees which seemed hardy and healthy. The fruit has the points of a a first-rate cooking apple, and is a fair eating apple,—a variety of great promise.

Dr. Regel describes several varieties of Sklianka, among others the Sklianka Revalskaya, a yellowish fruit, with a little

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red on one side, grown at Pskov, Petersburg, and other places, usually hardy, but sometimes injured in severe winters.

*Titovka (Titus apple).* A large, handsome fruit, to be seen in quantity in all the markets of the Volga and of middle Russia. It looks like a large-ribbed, elongated Duchess, and, on account of its large size and attractive color, very salable, and therefore very valuable. At Simbirsk it is considered one of the most profitable. At Tenki, near Kasan, it is a success both in nursery and orchard, and, from what we saw, would seem to have been grown there for many years. At Tula we see one very old tree of it, a survivor of an ancient orchard, killed by a severe winter many years ago. It is, therefore, a tree that thrives in the severest climates. It would not be safe to assume it to be quite as hardy as Anis or Antonovka, yet it is not very far from it. The flesh is coarse, but juicy and mildly acid, quite good, not at all disappointing, rather better than Duchess, because less acid. In season it is not one of the earliest, yet is a summer or late summer fruit. We might reasonably expect this to become one of the great commercial apples of our country.

*Ukrainskoe.* I was very much struck by a young tree I saw at Vilna, in full bearing. It looked as if bearing a crop of uncolored Northern Spy. At Orel we hear of it as a hardy tree and a good apple, but not as productive as some other kinds. Mr. Shroeder also notes it as a light bearer, but says the tree is hardy, and that it is a good cooking and second qualitied eating apple, which ships and keeps well. At Saratof we are told of an apple under this name that has been grown there for a very long time, said to be quite hardy in that climate, and to keep till March, and it is noted there as one of their profitable market fruits. In the milder climate of Warsaw our friends say, Why grow Ukrainskoe, a green apple, when you might as well grow a red one? Color in an apple is a very good point, yet I feel that any good late-keeping apple that thrives upon the Russian steppes is worthy of trial.

*Virginischer Rosenapfel.* It is strange how a fruit may wander to distant lands, and, generations after, return to its native land unrecognized. We first saw this in the nursery of the Pomological School at Proskau, and Mr. Budd declared that it

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must be the "Fourth of July." We then looked up the cast of the fruit in the museum, and so it seemed to be. Why should it have the name Virginia unless it had been there? and how, in those early days, get there except *via* England? Yes, we may suppose it to have been included in those importations from Russia made during the lifetime of the late Andrew Knaight, and thence found its way to Virginia. Its name becoming lost, it was grown westward and northward in America as the Fourth of July, and returns to Russia, the land of its ancestors, even if not the land of its birth, as the Virginischer Rosenapfel.

*White Koroshavka.* This is a favorite apple in the markets at Nijni Novgorod and Kasan, and is grown in fair quantity along the Volga for market purposes. It is an early apple, yet not one of the earliest, a fair-sized, white fruit, with little marblings and stripes of red; tender, rather juicy, and so mildly acid as to incline to be almost sweet, but nice and pleasant, invariably good, and therefore better in quality than Skrute, though perhaps hardly grown in as great quantity. We find it grown largely in the villages in Kasan, and apparently quite hardy there, so that its hardiness one need not have doubts about; yet a friend at Simbirsk, in a trying soil and situation, finds in the long run that neither the White nor Red Koroshavka is equal in hardiness to the Anis and Antonovka, yet for all that a hardy tree, and, I would say, a good summer apple, lacking neither in beauty nor in good quality.



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# THE GENESIS OF THE MERRIMACK VALLEY: ITS SAND, CLAY, AND TERRACES.

BY S. D. LORD, ESQ., OF MANCHESTER.

The state of New Hampshire is described as mountainous and hilly, and we know there are very few dwelling-places therein where the sun in his rising or setting does not veil his light by hills before leaving or mounting the horizon. There are depressions also through which the rivers and streams flow to the ocean.

On the higher lands the earth is indurated, and the soil is obstinate to the plow; but as we descend the valley and approach the great rivers, the soil is found gradually to be softer, until near the rivers it becomes pure sand, with here and there clay mounds by the rivers' sides. The banks of the rivers and streams in some places are precipitous, but often widen out into terraces of verdure, and sometimes three different terraces are visible, rich with the crops of grass and corn.

This is descriptive geography, and I am not content with description of present form alone. There is a history in the sand, clay, and terraces, which if correctly interpreted is both interesting and instructive.

Geology gives us description of the various forms of sand and clay in different ages of the earth, but we must look to astronomy for their genesis; and I invite you to go back with me, on the circle of time, to that period in the formation of the world when it ceased to be a star shining in its own light, and began to cover itself with a robe of earth, and thereafterwards became the dark planet. A part of this robe I have selected for the subject of my story.

It is fitting, in illustrating a theory, doctrine, or dogma, for the speaker to quote, from conceded authority, words and ideas

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which explain his subject and bring the elements of his discourse pertinently to the minds of his hearers; and I have to produce to you the theory of Laplace in the transformation of the solar system, viz.: A mass of highly heated vaporous matter occupied a space larger than the orbit of the most distant planet. By molecular and gravitating forces it acquired rotation, and threw off rings of matter which broke up into planets and their satellites.

Herschel embraced the doctrine, and further held that primordial, nebulous matter still existed, and is now being formed into nebulæ and clusters; and the theory has since been enlarged so as to embrace the universe in its operations, and that not only planets but even stars are now in process of formation, evolving from the nebulous matter.

We may have some idea of the immensity of this theory when the length of the space this revolving mass of heated, vaporous matter must have occupied is brought to our home mathematics. It is extended beyond the most distant planet, said Laplace; and Neptune is 2,750,000,000 of miles distant from the sun. This was as far as Laplace could go.

Herschel said it was now forming into clusters and nebulæ; and if we apply his theory to the elliptical nebula in Andromeda, the distance is not comprehended in miles: it is measured by the time that its light, travelling 190,000 miles per second, could reach the earth,—and this is 800,000 years. And had the light, at the time Herschel saw it, ceased, it would continue 800,000 years longer to shine before its light would be extinct here. But the theory is now extended beyond this nebula to stars whose light started millions of years ago towards us, and has not reached us yet, and will not reach the world for millions of years to come, even at the speed of 190,000 miles per second. The intellect does not, cannot, comprehend the immensity of the universe.

Through all this space the nebulous matter was rotating, propelled by gravitating and molecular forces—powers now in operation. The earth swings 68,000 miles every hour in its orbit around the sun. Daily at the equator it has to revolve upwards of a thousand miles per hour. The stars, the planets, are in motion propelled by the same forces that first gave motion to

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the nebulous mass of which all were composed. Nearer now, it is the force also that moves the pendulum, and even weighs the groceries we consume. This is gravitating force.

Molecular force gives heat, chemical action, light to the sun, to the lamps, and to the carbon. These forces accompany matter, originally giving it motion; and in the modest duty I have to do in regard to the earth, the sand, clay, and the terraces, it is to them I must refer for primary power. Let me illustrate in the language of Prof. Youmans: "In melting nine pounds of ice," says he, "heat changes the position of the atoms, and confers upon them the potential energy of water. Additional heat drives the atoms further asunder, and confers the higher potential energy of steam. Still further, heat, or an equivalent force, decomposes the steam, forming one pound of hydrogen gas and eight pounds of oxygen gas, with a still higher state of potential energy. Now, in returning to those former conditions, they give out an actual energy exactly equal to their potential energy. The clashing force of the atoms, as they revert to the successive states, has been represented by the fall of a weight down three great precipices. The first fall, the collision of the two gases, is equal to the plunge of a ton weight down a precipice 22,320 feet high; the second fall, the condensation of the steam, is equal to the descent of a ton down a precipice 2,900 feet high; and the third, the freezing of the water, is equal to the fall of a ton weight down a precipice 433 feet high." And Prof. Tyndall, referring to the same molecular power, said,—"I have seen the wild stone avalanches of the Alps, which smoke and thunder down the declivities with a vehemence almost sufficient to stun the observer; I have also seen snow-flakes descending so softly as not to hurt the fragile spangles of which they were composed,—yet to produce from aqueous vapor a quantity of that tender material which a child could carry, demands an exertion of energy competent to gather up the shattered blocks of the largest stone avalanche I have ever seen, and pitch them to twice the height from which they fell." With this explanation of these universal forces, acting constantly in every way, we will again proceed to discuss the mass subject to them.

In the consolidation—condensation—of the nebulous gas, it would next assume the condition of a liquid, and, like the drops

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of water under the force of cohesive attraction, would be of spherical form. Magrini, a Florentian writer, says,—"The same cause which gives rise to the limpid drops of dew which sparkle on the leaves of plants, and which combines into small spheres the particles of water, has given to all the celestial bodies their spherical form." And Prof. Henry adds,—"The spherical form of the planets is due to the attraction of every particle of the whole body on every other."

Now came additional heat—condensation produces heat—and the heated gas became a mass of liquid fire, as we have seen a globe of fire. Another change awaited the mass. It began to cool, to radiate its heat into space, and in time a hard shell formed around the whole, and the star glittering in its own light became the planet earth. The oxygen and nitrogen had combined to form air, and the hydrogen with oxygen formed the water. The incipient earth now began. The elements composing the fiery mass were the same when they became solid. The change was in structure and conditions.

Now let us apply a principle, that every one of us knows to be true in his own experience, to the earth's shell when cooling, viz., *heat expands and cold contracts*, and study results. As it cooled it would contract, and, being in the form of a sphere the circumference three and one-seventh times greater than the diameter, the shrinkage could not be symmetrical in every part; and it is evident that the cooling, contracting matter within the crust could not be followed by the outer shell as it fell below, and the more the molten mass contracted and shrunk within, the more wrinkled and uneven would be the surface of the more hardened shell.

In this shrinkage it could not retain the symmetry of the round shell that it probably had originally, and the result of this action, upon both surface and the internal mass, is the form in part presented us to-day of mountains and valleys. This we will say is initial and primitive, for we cannot conceive the work of erosion without presuming previous inequalities on the surface.

The lines of the Rocky Mountains—the Andes retain their elevation—the Alleganies, and the Apalachian range remain, but the valleys of the Mississippi, Missouri, and Ohio sunk. Hills

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remain: those running parallel to the Merrimack maintain their elevation in part, but the plains of the valley on which the cities are built fell with the valley, and Manchester, Concord, and Nashua lie in the folds of the collapsing earth. Such, we say, were primitive, but some original elevations have fallen through earthquakes, and others by erosion have been levelled and even sunk to valleys; and these changes have been modifying the surface from the first, and at no time have they ceased to act, and never will till the fires within the earth are extinct.

It is at this point our thoughts should go back in imagination to those times,—I do not say *days*, for it may be the deserted sun was not able to pierce the clouds that covered the earth to divide the day from night,—*times* when convulsions and earthquakes were common events, when storms were showers of lava and ashes, and in an atmosphere tempered, too, only with blasts of the consuming gases.

In these conditions we may suppose the internal gases accumulated and burst through the shell, and that the shattered fragments fell with an awful crash down to the seething fluid beneath; that the smoke and ashes escaped through the craggy chasm of the crust into the new-formed air;—then followed hissing tongues of fire thousands of feet high, licking the dense, dark atmosphere, falling back in currents of lava, trap, and granite, all the work of gravitating and molecular forces in the revolving mass. I cannot describe the reality. The simultaneous discharge of the artillery of the world in park together could not equal the roar of the elements. The earthquake's shock of to-day is a faint comparison, while the cyclone is much too insignificant to compare.

It was the destruction of the old form and the construction of a new: it was the birth of the earth in evolution.

Indeed, this little spot, New Hampshire, so pleasant to us, responding to the seed sown in the spring with abundant harvests, with pleasant skies, was moulded, wrinkled, into mountains and valleys in just such convulsions.

In my story I have reached that condition of the world when it assumed the shape substantially which we have to-day, its ribs of rock growing thicker as the cold winds of space began to blow upon its surface.

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Then began the work of clothing the naked rocks; and we meet in every step of our progress with the work of the same gravitating and molecular forces. Agassiz, once standing on the rocks of Canada, said to his companions that they were upon the first land formed upon the earth—referring to the Laurentian formation. It was the oldest rock. It was indeed but little adorned with fossils. The treasury from which the earth was supplied was large, but vacant. There was the eozoon Canadense, the first known life, and it was engraved upon the rocks, and in that form was transmitted to us. Then the Cambrian addition was made to her attire, with its improvements in fossils; and so at every era more linings were added, of various patterns and colors, which the different ages required, ornamented with their peculiar fossils, and fringed with the embellishments of the times, till now some 37 successive additions, according to Lyell, have been made in the strata covering the rock-ribbed earth, each improving on the preceding. In some of the pockets of these robes we find the coal, stored for our use so long ago; in some the clay and sand; in others, limestone,—all stored with a prescience of future utility.

But I must leave these various strata in this discussion, for, however beautiful and interesting they may be, they are not particularly pertinent to my subject, although perhaps intimately connected with it. My duty pertains to the sands and clays.

The rocks have the same specific gravity they had when molten; whence it follows, in a liquid mass, the parts composing it, if not homogeneous, would take position according to their gravity,—the heaviest at the bottom, the lightest at the top. In a sphere of melted sand, feldspar, and mica, these would be arranged according to their specific gravity. Sand, with a specific gravity of 2.3 to 2.6, would be on top, above the feldspar at 2.55 to 2.74, while the mica would fall to the bottom at 2.61 to 2.99. Silver is weighed at 10.50, and gold at 19.34, and if present in the sphere would be found the very lowest.

These rocks we would expect to find at the surface of the melted mass; and such is the fact. The sand-stone at the surface would be the first to cool. It is very abundant, and in decomposition gives us sand. The alumina of the mica and feldspar, which, coming next in order, gave the clay, and this

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was abundant. The sand and clay then were the first to appear from the disintegrated crust. The desert of Sahara consists of shifting sands in places, but the greater part, says a traveller, is of a naked form, composed of firm and indurated sand, sandstone, granite, quartz rocks, often rising into ridges and hills. All is not pulverized and disintegrated yet.

It is not necessary for me in this paper to go further for sand and clay. We now know their genesis.

It is well to turn our attention a moment to the forces acting to crumble, disintegrate, and pulverize the crust of the earth as the cooling went on, and we know the same forces are doing like work at the present time. These forces are gravity, water, heat, cold, wind, chemical and vibratory action, and others.

Rocks tumble down declivities, rumble down mountains, and are worn away. The tendency of all matter is downward. The metal rod grows shorter by standing upright. It is said that sheets of lead with which the roofs of buildings are covered grow thinner in their upper part and thicker at the bottom. Farmers will tell us that the loose soil works down the hill; that it is thicker at the base than at the top. The force of gravity constantly acting is the great leveller of movable matter. Water is a most powerful agent in the work of erosion. At 212° it is converted into steam: above that temperature steam is its natural condition. It seems almost incredible, but we must consent to the meteorological truth that all the waters of the oceans, lakes, and rivers now existing were, in those ancient days of heated matter, in the atmosphere in vapor. Water covering three fourths of the face of the globe is a vast quantity, yet we have no right to believe any has been added or lost since it first condensed. It was all in the air then in the form of vapor. This was inevitable.

We see here what vast potential energy was stored in the heavens for use upon the cooling earth: water in rains, then in streams, then in floods, began to play upon the surface, and carry the sand and clay from the rocks to the depressions below.

The temperature of space, as found by Sir John Herschel, is 239° below the zero of our thermometer, and its cold fingers began to work upon the crust. Alternate heat and cold contract and expand and break the rocks in pieces, and the winds

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scatter their dust. In 1881 I saw, on the highland in rear of Concordville, York Beach, a rock weighing a ton or more, apparently disintegrating. In 1882 that rock had entirely decayed and pulverized, and the winds had blown it away even with the ground.

Many of the rocks contain potash, such as mica and feldspar, and such yield easily to the oxygen of the air and water. The falls of the Amoskeag are paved largely with rocks containing feldspar. They are already worn much, and, though huge and bold, their end is in the near geological future.

The continuous vibratory motion common to all bodies acts powerfully upon high elevations. The walls of the observatory of Milan were found to be subject to certain periodical and variable oscillations, due to the action of the sun. Prof. Hosford found Bunker Hill monument to incline to the west in the morning, north at midday, and east in the afternoon, and the late Prof. Henry said the same vibratory motion was observed in the capitol at Washington. A plumb line from the roof of the rotunda to the pavement described an ellipsoidal curve, of which the longer diameter was four or five inches in length; and he remarks,—"By molecular actions of this kind, perpetually continued, time, 'the slow but sure destroyer,' levels with the ground the loftiest monuments of human pride." These forces are acting in different ways upon matter without cessation. They have acted upon the original crust, and the sand, clay, and fossiliferous strata are the result. This is erosion, for all the forces of nature are working to destroy the rocks and convert them to the simplest forms.

The dissolution of mica gives sand and clay; feldspar gives the same in different proportions; and all rocks give sand. The mills of nature are ever grinding, and they furnish an abundance.

When the waters that were retained in the atmosphere in such immense quantity began to pour down upon the naked rocks, which would occur as soon as the temperature was reduced below 212°, the action would be direct to wash away the particles of sand from the rocks to the depressions, to the valleys. Stratum upon stratum would be formed, varying in thickness according to the erosion.

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When these depressions, valleys, were filled with the sand so washed down, they would be plains. In this way were formed the strata of the fossiliferous ages, gravity acting through everything and in every way to reduce the old rocks to a level.

We look upon plains as basins containing the collected *débris* of the rocks, transported in part by their own gravity, but in the main by water. If you will dig down deep into these plains, you will find sands of different color, different characteristics, evidently of different age, and they will be plainly marked so that the eye will detect them at once; and it will show us also that they were once covered by still water, but we often will see the evidence of the eddy. It is manifest that these depressions must have been filled with water before the sand was there, and that the lakes were supplanted by the sand. But there were plains stratified, and the strata have been baked into solid rock by subsequent heat, and they were filled with marine fossils: hence we know they have been raised from the level of the sea, and, so far as the geologist has advanced, excepting volcanic and igneous formations, the stratified rock is found at all elevations and at all depths, and we infer that the waters once covered the entire face of the globe until driven by subsequent elevations to its ocean bed. Such changes will continue so long as the original forces, gravitating and molecular, rule in the universe.

We have reached that point in our discussion where we may turn to the terrace and study its construction. Recently the attention of the geologist has been in that direction, and they are treated as deltas, sea terraces or beaches, moraine, lake, and river terraces. The deltas are deposits of the detritus of the rivers. The deltas of the Nile have been known several thousand years, and the habits of the river also have been studied, and no variation in manner of formation has been discovered in that time. The same thing may be said of the deltas of the Mississippi. They are the deposits of that great river, and everything of a mineral character that can float is carried down and deposited at the delta. This amount annually is sufficient to cover a square mile 268 feet deep. The result is, the river in a measure is dammed up by the sand, and in times of flood channels are cut through the deposited sand.

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Beaches are the shores of the sea, where sand is washed in storms above the tide waters, and which does not follow the retreating waves. Moraine terraces are irregular,—more so than others,—and are supposed to be formed by stranded ice. Lake terraces and river terraces are somewhat alike,—one by still, the other by moving, waters. The formation of river terraces is very much in the same way. So if we study the construction of the terraces on the Merrimack we shall also comprehend those on the Connecticut.

Geologists have limited the construction of the terrace to late periods. We are told by them that during the glacial age New England and Canada were elevated,—the latter 1,000 to 2,000 feet; and this they argue from the fact that old sea beaches are found near Boston from 75 to 100 feet above the present beaches; that shores and beaches are found on Lake Champlain 393 feet above tide-water, and that the remains of a stranded whale were found there; that the glacial age was followed by one of depressions, and this they call the Champlain epoch; that during this age the ice melted, causing the lakes and rivers to overflow. Mr. Croll fixed the time from 80,000 to 240,000 years ago; others go back 850,000 years. I made, some months since, study of the temperature in the last aphelion winter, and was made to believe that New Hampshire, 12,000 years ago, was covered with snow and ice hundreds of feet thick, and even thousands, that resisted the summer sun, remaining and increasing till the perihelion winter swung into its present place. The reasons were astronomical, and were founded upon the precession of the equinoxes and the greater obliquity of the ecliptic. As this matter is just beginning to be studied, and few comprehend it, let me explain briefly. The path of the earth around the sun is the form of an ellipse, and the sun is at one of the foci. A line drawn through the two foci of the ellipse is called the line of apsides, and the points of contact of this line with the ecliptic are called perihelion and aphelion, the one nearest the sun being perihelion, and the other more distant, aphelion. This point of perihelion moves around the sun in about 25,000 years. So the earth, if in perihelion now in winter, was in aphelion the same season 12,000 years ago, half-way round. We are now prepared to consider the climate of that period.

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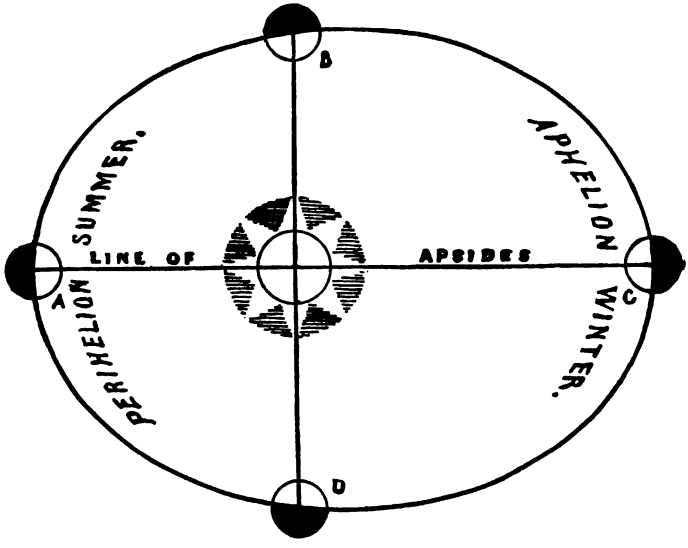
This will be better understood by studying the diagram, which I have used in a previous paper, representing the positions of the earth and sun with reference to the ecliptic 12,000 years ago. But we must remember the positions at the present time are the reverse of those 12,000 years ago, our present winter being in perihelion with the earth at A, moving in winter from B through A to D, and describing the arc D, C, B in summer.




The ecliptic, it will be seen, is represented an ellipse in form, the earth moving round the sun in the direction of A, D, C, B. The line of apsides now varies about 10° from the equator.

In perihelion the earth is 3,000,000 miles nearer the sun than in aphelion, and is now that distance nearer the sun than in winter of the aphelion period. We may find the temperature of that period. The rule of inverse squares applies to heat as well as light, and we may make a proportion: the result will be the temperature of the aphelion winter, provided we know the amount of heat the sun now gives in perihelion winter. Sir John Herschel found absolute zero with reference to the atmosphere to be 461°, and stella space 239° below the zero of our thermometer. Now the winter mean temperature in this state is

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about 23° above zero, and, as all above 239° is due to the heat of the sun, if we add 23° we have 262° due to the sun. Taking the perihelion distance at 90,000,000, and the aphelion as 93,000,000, we have under the rule of *inverse squares*, viz., $(93)^2 : (90)^2 :: 262°$, which we will find to be about 242°, that is, the difference will be 20°. This would reduce the present temperature of 23° to 3° above zero for winter.

It is an astronomical fact that the sun 8,000 years ago, according to a formula given by Mr. Stockwell, found in the 18th Vol. Smithsonian Contributions to Knowledge, went to a solstitial point 24½° south of the equator; it is limited now to 23½°. The difference is nearly a degree. Now the sun is some four days in passing a degree of this obliquity—going and returning would require eight days—which eight days are so many days of mid-winter in addition. In an aphelion autumn and winter there are eight days more than of spring and summer, which change places on the ecliptic, since now we have 186½ days of summer and spring, against 178.7 of fall and winter. This, and the 1° obliquity, would give an absolute change of some 16 days to be added to the aphelion winter, but a change of 32 days relative to the present perihelion winter, since, if you add to winter 16 days, it would take so many taken away from summer. Mathematically, we would take 16 from one side of the equator and add it to the other. This is quite important, since the mean temperature of 23° we now have is with a winter 32 days less than the aphelion winter. Let us reduce for this 6° from the present mean, which gives us 26° to be deducted, and leaves us a temperature of the aphelion winter at 3° below zero for four months.

It is very easy with the temperature we have found averaging annually less than 32°, the freezing point, to produce the snow and ice-sheet of great thickness. The annual rain fall here is about 4 feet, and if we concede one fourth of that to this purpose, in a thousand years we should have a thousand feet of solid ice; or if snow in its usual form, allowing 10 inches for every inch of water, there would be 10 feet annually, ten thousand feet in a thousand years. This condition would continue for at least one third of the time of the precession period, about 7,000 years.

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In opposition to this is the fact that the summer sun would be 3,000,000 miles nearer, and the increased heat would compensate for the loss of it in winter.

But the answer to this is the meteorological principle that the heat is absorbed in melting the ice and snow of winter. It is said by Mr. Meech that "a dense and lasting fog prevails after the middle through the rest of the summer season, and effectually prevents the rise of temperature which the sun's intensity would otherwise produce." This was spoken of the high latitudes. We also see this principle exemplified in the difference between the temperature of autumn and vernal equinoxes, one following winter and cold, and the other following summer and warm.

From the 10th of March to the 20th, and from the 20th of September to the 1st of October, every year, the sun is in the same relative position with reference to the equator, and the same angle to the earth and at the same distance, yet the temperature for those ten days in March, 1884, at Manchester, was 37.70°, and for the ten days in the following September was 61.77°, a difference of 24.07°.

These are my reasons for an ice period 12,000 years ago, which is intermediate but constant, and does not conflict with those of higher eccentricity, but really is a reason for their greater intensity, if happening in aphelion winters.

After this digression let us return to the terraces.

In the thawing of the ice and snow of the glacial period, the valley plains were cut through by water and ice, and the old depressions, which were made flood plains, were in like way channelled by the melting ice; and the remains of such plains are the terraces of to-day, modified of course by subsequent floods. The terraces on our rivers are the wreck of old plains generally, but sometimes of change in the channel.

If we watch the rivers flowing through alluvial valleys, we see they are constantly changing their course, washing sand from one side and depositing like on the other, sometimes filling up old channels and making new. There are terraces, we call them intervals, on the Merrimack, formed in this way, where the channel is in the act of changing now, and such are not attributable to the floods following the ice period, but to present spring freshets.

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In regard to the changing current of the Merrimack there has been litigation, and a decision has been made with regard to the rights of riparian owners—*Gerrish* v. *Clough*, 48 N. H. 9. The channel was gradually changing "by wearing away the bank" on one side, and "adding and forming accretions upon the opposite shore." The court held such accretions became the property of the land-owner on that side, but that the owner on the other side may "protect his bank from further encroachment by rubbling or other means, provided it does not cause a change in the [then] accustomed channel of the river to the material and appreciable injury of other riparian owners"—no one having a "right to build a dam, break-water, or other obstruction in the stream, which will raise the water upon the plaintiff's land or wash the same away." But it seems if you protect your land you must do it in such a way as not to injure the opposite proprietor.

We have found in the sinking of this valley of the Merrimack that the initial depression began when the globe began to cool. I do not think these depressions were continuous from the Winnipesaukee to the ocean, but a succession of depressions, divided by ridges, parts of which have resisted the destroying forces of nature, and are now to be seen. We must go to the Champlain epoch, or a similar later thawing period, for the power which broke through these barriers and made the valley a continuous depression, ages succeeding the glacial.

The effect of the glacier moving down these plains, through the lakes, would be to scoop out a channel of everything movable in its way. So the barrier at Hooksett, a hundred feet high or more, was pierced by the ice and water, and that too at Amoskeag gave way; those below also yielded, and the flood-stream became the Merrimack river. Then as the barriers and intervening ridges of the valley were torn down by the ice and flood, the shore lines of the old lakes receded again, and again receded, until a channel was dug out deep towards the crust, cutting through the sand at various depths, washing the shores of new-formed channels, and thus formed the banks into terraces, presenting the form they now assume after centuries of modifications and changes.

I look to the time when the reservoirs of the Winnipesaukee

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and the Massabesic were plains of sand, covered with water of much greater extent than their present boundaries—of greater depth also, which sand the ice and floods have taken out and borne down the current.

So we may apply our theory and reasoning to nearly every stream, and trace back its history in the sands on its shores. We may look to plains, that appear to be independent of all such erosions and destruction because they have escaped the wreck of thawing ice periods, as certain to pass in the same way in the future cataclysm, into the wreck of terraces.

The thousand increments, subtractions, with the changes of to-day, make the world of tomorrow, under the developing powers of gravitating and molecular forces ;—and this is the way nature works, and we call it evolution.



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# ALDERNEYS AND GUERNSEYS.

BY JAMES L. GERRISH.

About two years ago, after inspecting the best Guernsey herds about Boston and vicinity, and visiting the so-called Alderney herd of Mr. Barnard, of Hopkinton, we wrote about Alderneys and Guernseys, comparing the two breeds without being able to separate them, and stating at the summing up that if Mr. Barnard's cattle were Prince importation from the Alderney island, they were most surely of the Guernsey type, having quoted what had been written about the two kinds on the islands of Alderney and Guernsey by one Dr. L. H. Treadwell, member of the American Jersey Cattle Club in 1865. It being some two years since the letters were written, and the interest in these cattle having steadily increased, we venture to repeat that quotation, with some others, for the benefit of those readers who desire to post themselves concerning these popular breeds.

Dr. Treadwell then wrote, on his return from the Channel islands,—"The cattle of the Alderney island (which is third in size of the Channel group) have a want of uniformity, attributable to the fact that they are the offspring brought from Jersey and Guernsey, crossed and re-crossed until all individuality as a breed is lost. Some are neat and deer-like; others are larger and heavier, approaching the Guernsey type."

Of course he was speaking from a Jersey Cattle Club standpoint. We quote what a Jersey breeder says in the *Country Gentleman* of July 10, giving his view of what constitutes in his opinion a good cow. Capt. Le Brocq writes, speaking of the fancy points,—"A Jersey cow should be a proper butter machine. * * * Only last week, at our royal show, what did we see? The best dairy cows not even looked at. However,

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one of our breeders managed to sell a six-year-old cow, red and white, whose sire and dam are unknown, for £200. Her sworn butter record, taken from the butter test record book of the Jersey Farmers' Association, showed that in seven consecutive days she had given nineteen pounds three ounces of well worked and salted butter ready for market."

These, said he, are to my mind the cows to breed from; and for years, like others on the island, I have not exhibited because I found that fancy points often outweighed the solid pounds of butter, in a show-yard. So we have no doubt that on the island of Jersey as well as Alderney there is a mixture of types of cows, if not a mixture of bloods, although they claim heavy penalties for mixing with the blood of the other islands of the Channel group. We are very confident of one thing about the herd-book of Jerseys in this country, without mentioning the names of any breeders, or even nominating any particular family of H. R. Jerseys, and that one thing is this: While there are innumerable "deer-like" cows with "fancy points," those from which the herd owners usually expect the best tests and the greatest yearly profit in the dairy are what they choose to call "old-fashioned Jerseys." These same cows in almost every instance partake largely of the Guernsey type. One prominent breeder told me in private that he was sorry he had not saved every calf from a certain noted bull (recorded in the Jersey H. R.), even those buff and red and white calves "of the Guernsey type," which had been sacrificed on account of *color*. We believe the best cows at the New England fair last fall, taking apparent production of milk and butter as the criterion, were sent from Maine, and their printed pedigrees showed a very large per-centage of "Taintor importation" in their ancestry. These were large, old-fashioned Jerseys. Mr. Barnard's cattle, which were never entered in any herd-book (since the A. J. C. Club was formed), are known to be of the "Prince" importation. Col. Waring, former secretary of the American Jersey Cattle Club, once wrote in the *American Agriculturist*, as near as we can recollect, that the Prince and Taintor importations were the best ever made.

We believe this was true; and why not? As long as Prince, Taintor, Col. Colt, and Nicholas Biddle imported from the Chan-

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nel islands, they could purchase the choicest cattle that were bred or owned there, and that at no great first cost on the islands, as the great demand had not begun, the cattle being very little known here; while for the last ten or fifteen years the demand has increased to little less than a mania, creating something such a state in the market as existed in war times with the merino sheep trade. At that time any little, ill-bred, thin-shanked merino lamb would have a ready purchaser at $10 or upwards, simply because pure merino!

We believe in the present integrity of the officers of the A. J. C. Club, and have no doubt the originators of that club acted up to their best light and judgment, even if they voted in some cattle at the commencement that might possibly have had Guernsey type, if not actual Guernsey blood in their veins. The Jersey breeders having had such liberal advertisements at the hands of all agricultural, yes, and the majority of the secular and religious, papers of the country, and, writing for the farmers of New Hampshire rather than for gentlemen farmers in particular, we ask room to give an unsolicited quotation in description of the Guernseys. The description is enthusiastic—almost poetic; but after spending a day in the Jersey and Guernsey pens at the Centennial, visiting the New England fair for years besides many fairs in this and other states, owning a few registered Jerseys of fashionable blood and family, and also crossing the registered Jersey with Alderney or Guernsey cattle extensively, we say unhesitatingly, if out of a stock of dairy cattle to-day, and wishing to procure a good working butter stock, viewed from the farmer's standpoint, we should surely buy those registered or unregistered Jerseys showing the Guernsey type, or try for a herd of pure Guernseys. Here is the description of the breed by Mr. T. D. Mouilpied, honorary secretary of the Royal Guernsey Agricultural Society, read last May at a meeting of English breeders of Guernsey cattle:

"It is not a question of beauty alone that we are pleading, but one of quality and beauty combined. When we come across a Short-horn or a Hereford, the first impression on our mind is, What a fine beef animal!—when we see a Jersey, our first thought is, What a pretty little beast!—but when we meet a

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Guernsey, the first and lasting impression on our mind is, What a splendid milch cow! You see it in the broad, golden rim encircling her eyes, in her glossy horns and hoofs; you see it in the orange color of her skin, sometimes so full of yellow dandruff as to appear as if the animal had been powdered with gold dust; you see it in a skin as soft as velvet, in her long head and neck, deep, wedge-shaped shoulders, in these long, prominent milk veins; and finally, you scent it in that large, deep, well-filled silken bag, so yellow, and enveloped by a skin so soft, so fine, and so thin, as to almost appear transparent; and lastly, if you are still incredulous, a look inside the ear will be sufficient to convince you of the excellency of the animal before you. But add to these points—so essential to a dairy cow—her benevolent-looking head, with its large, dreamy eyes and clear, buff nose, and the beautiful coat of red or lemon fawn and white, and you are justified in adding the word beautiful to the quality of good.

"A very important feature of the Guernsey breed is its aptitude to lay on flesh, as the following figures, taken from the Royal Agricultural Society's reports show: In 1877 Mr. George Allez exhibited a cow aged 14 years 9 months, which weighed 644 pounds of dressed meat, and at the same show Mr. T. L. M. Laine exhibited one aged 18 years, which gave 579 pounds. In 1882 Mr. R. Best's heifer, aged 3 years and 6 months, realized 900 pounds of dressed meat, and Mr. P. G. Mollet one aged 3 years 2 months, which gave 749 pounds of dressed meat.

"We cite these figures without attaching any special importance to them, as they often occur at our shows,—our object in doing so being, firstly, to prove to the English farmer, with whom beef is an important feature in breeding horned cattle, that the Guernsey cow is not ungenerous in the fattening stall, and that after eighteen years of good dairy work she may still be turned over to good account; and this is the more striking when we consider that hay, a small allowance of meal, and roots constitute her only food. It must also be borne in mind the Guernsey pound is about two ounces heavier than the English pound.

"One more important feature of this breed is its power of

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fixing strains. It is a well-known fact that young animals throw back and develop the traits of a remote, rather than those of an immediate, sire. Here, thanks to the purity of blood, the traits are fixed,—there is no 'striking back;' and this is so strong that often it is difficult to detect the cross from pure stock, so strongly is the offspring similar to its sire. This is applicable to this breed alone, and is of the greatest importance to those who grade up herds for dairy purposes."

We have omitted many of his heaviest weights for want of space, one of which was a steer 2 years and 8 months old, that dressed 1,169 pounds.

Mr. Barnard has reported dressed weight of cows to us as high as 720 pounds; and as regards age, we know one of the early cows from the "Prince" stock to reach nineteen years of age, breeding until sixteen. We have a cow, sired by one of Mr. Barnard's senior's bulls, which is bright and hearty at 17 years of age. Her butter has taken numerous prizes at local fairs, and although unregistered, her heifers would sell before coming to milk for twice the price of common stock. She is in calf from her grandson, and looks as though she might live to breed again.

Since penning the above we find in the August *Agriculturist* on editorial on Guernsey cattle, with a cut of cow and bull. We can quote but very little, but desire to use that part regarding the admixture of Island bloods. The writer says,—

"Her butter is much higher colored than the average Jersey cow's. So intense indeed is the color, that the presence of one Guernsey in a herd of six or eight common cows, or of eight or ten Jerseys, will give an agreeable tint to the butter all winter. * * * Some cows within our knowledge have approached three pounds a day. * * * Jersey breeders from perhaps the earliest periods have enriched their strains of breeding by the occasional introduction of Guernsey blood. In fact, it is a conceded point that the variable richness of color possessed by the Jerseys is largely due to a remote Guernsey cross. The appearance of the late well-known cow Jersey Belle, of Scituate, is cited in illustration of this manner of breeding."

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Far greater weights are given by the editor than any we have before quoted,—one a steer reaching 2200 pounds, live weight. He recommends Guernsey bulls for those farmers desiring to make veal of their calves, whereas pure Jerseys are known not to fill the bill as veals. We know of no objection to the veal thus produced, except that the meat and tallow are so yellow in color as to frighten the uninitiated by suspecting some disease.

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# THE COW PEA.

A few years ago the chairman and secretary of the board procured from North Carolina a few bushels of the cow pea, to test as a forage plant. These were sowed on sandy soil, and yielded a good harvest of forage, and some of them matured sufficiently to grow. We might have preserved a quantity for seed, had we supposed in time they would ripen. The stalks grew to be from one foot to three feet high, depending on the fertility of the soil.

The experiment was sufficient to show what could be done; and we wish now to say to the farmers of our state, and especially to the diarymen, that this will be a valuable crop for us to cultivate. If parties desire it, and will notify seasonably, the secretary will send for a quantity.

Dr. LaDoux, now of New York, once director of the experimental station at Chapel Hill, North Carolina, urges the cultivation of it for green manuring, for fodder, and for the grain. We copy some of his remarks and the result of his analysis.

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This plant is peculiarly a "Southern institution" as yet, and prized as it is by some farmers who understand its value, it is nevertheless astonishing that so little use is made of its excellent feeding qualities, its wonderful power to recuperate our worn-out sandy lands, and to serve as a fallow crop and weed-destroyer. Its beneficial effects may be divided into two classes—mechanical and chemical.

The mechanical advantages derived from sowing the pea are more or less those obtained by sowing any green soiling crop. They are chiefly due to the covering of the soil.

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Comparatively little has been written (or if written, accessible) in our agricultural journals about the cow pea, nor has it ever before been carefully analyzed, so far as I can learn. In the *Charlotte Democrat* of May 9th we find the following, which is a popular description of the

"STOCK OR COW PEA.

"The growth of the stock pea is interesting, because of its value as a fertilizer and for hay to the farmer. There are several varities grown here, all distinct from each other in color and value. The 'Whippoorwill' is small and speckled—makes but little vine, and is in little demand. The 'Crowder' is of a clay color—the largest of all and most salable because of its handsome appearance and valuable properties. It is not prolific at all, and is hard to raise. There are seldom any in this market. Its name arises from the crowded manner the pease grow in the pod. The 'Black Pea' is worthless, except for green manuring and hay. It makes enormous vines and little fruit. The 'Black-eyed Lady' makes little vine, is fine feed, comes early, and is considered the best for the table. The 'Clay Pea'—the most popular, and the best of all for everything for which the pea is used—is now selling here for seventy-five cents per bushel. I mean that merchants are paying that price, and holding for better prices before selling.

"The peculiar characteristics of this pea are as follows: It has no tendrils, but twines like beans, or runs upon its own foliage. It is of rapid growth, making in three months, on ordinary land, an almost impenetrable mass of foliage two feet high, and so very dense that it destroys all other vegetation—even the thistle, ragweed, and other noxious weeds. When well cured, these vines are simply invaluable for hay, worth, as ascertained by actual experiments, thirty-three to fifty per cent. more than timothy. The only difficulty in making them the leading crop for hay, is that it takes three days to cure them. Cattle and horses prefer such hay to the best herds-grass, and even to corn. Pea vines are the best fertilizer we can use. By experiments, one crop of pease, turned under in July or August, has proved equal in value to a two-year-old clover sod. Full of nitrogen

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and water, they decompose in a short time. I have frequently cut off the vines before they began to run (in July), and by August the roots would throw out new vines two feet long. So far as raising the stock pea for seed, or sale, further north than this (Va.), it would be impossible.* This climate and our seasons have all they can do to ripen the crop here. We sow the first of May, and they never ripen earlier than the last of August or the middle of September."

The botanists recognize some sixty or more species of *Dolichos*—some natives of the old world, some of the new. Several species are said to be cultivated in the South, as has been already shown. Two varieties were analyzed, as will be found below. The species are not well defined in all cases, and there are many hybrids, as every farmer knows. Though called "pease," they are more nearly related to the bean. The history and identity of this interesting plant are still very obscure. The farthest north that any extensive experiment has as yet been made with this pea, so far as I can learn, is in Monmouth county, N. J., where very heavy crops were obtained in 1877. A visitor to the farm writes for the *American Agriculturist* as follows:

"On approaching the farm we encountered one field. There may have been seven or eight acres in it, and the pease covered the field so that the ground could not be seen, nor the faintest color of it, even where the plants were most erect. Where they were lodged, as most of them were, they formed a dense mat, one or two feet thick. No sunlight could penetrate to warm the soil; not a weed could start; and as a fallow crop and weed-killer, I can hardly imagine anything superior."

The *chemical* advantages derived from the cow pea, both for feeding purposes and for renovating the land, will be explained in part by the accompanying analyses.

The samples for analysis were taken in the field when the pods had just begun to turn yellow, and contained ripe seeds (in September). The vines were still green. They had grown upon sandy soil:

*The writer is mistaken in this, as will be seen by our remark above.—SEC.

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## ANALYSIS.

### *Samples of Black Cow Pea.*

FRESH SEED.

| | *Per ct.* | |
|---|---|---|
| Moisture | 20.85 | |
| Ash | 2.94 | *Per ct.* |
| Albuminoids | 20.08 | Containing ammonia, 3.89 |
| Cellulose | 4.34 | |
| Fat | 1.28 | |
| Carbohydrates | 50.51 | |
| | 100.00 | |

WATER-FREE SEED.

| | *Per ct.* | |
|---|---|---|
| Ash | 3.72 | *Per ct.* |
| Albuminoids | 25.37 | Containing ammonia, 4.91 |
| Cellulose | 5.48 | |
| Fat | 1.62 | |
| Carbohydrates | 63.81 | |
| | 100.00 | |

### *Sample of Yellow Cow Pea.*

FRESH SEED.

| | *Per ct.* | |
|---|---|---|
| Water | 19.20 | |
| Ash | 3.31 | *Per ct.* |
| Albuminoids | 23.02 | Containing ammonia, 4.46 |
| Cellulose | 5.03 | |
| Fat | 1.37 | |
| Carbohydrates | 48.07 | |
| | 100.00 | |

WATER-FREE SEED.

| | *Per ct.* | |
|---|---|---|
| Ash | 4.10 | *Per ct.* |
| Albuminoids | 28.50 | Containing ammonia, 5.52 |

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| | |
|---|---|
| Cellulose | 6.23 |
| Fat | 1.68 |
| Carbohydrates | 59.49 |
| | 100.00 |

*The Ash of Yellow Seeds.*

| | Per ct. |
|---|---|
| Ash | 3.31 |
| Potash | 30.16 |
| Soda | 11.72 |
| Magnesia | 6.16 |
| Lime | 4.84 |
| Phosphoric acid | 30.06 |
| Sulphuric acid | 3.33 |
| Silica | 1.65 |
| Chlorine | 0.35 |
| Oxide of iron | 0.39 |
| Carbonic acid | 8.10 |

*Composition of Ash with Silica and Carbonic Acid deducted.*

| | Per ct. |
|---|---|
| Potash | 33.42 |
| Soda | 12.99 |
| Magnesia | 6.83 |
| Lime | 5.36 |
| Phosphoric Acid | 33.30 |
| Sulphuric acid | 3.69 |
| Chlorine | 0.39 |
| Oxide of iron | 0.43 |

From these analyses we can see that the composition of the fresh seeds of the yellow variety is as follows, in 1,000 parts:

| | Parts. |
|---|---|
| Water | 192.00 |
| Potash | 10.08 |
| Soda | 3.98 |
| Magnesia | 2.14 |
| Lime | 1.78 |
| Phosphoric acid | 10.05 |
| Sulphuric acid | 1.09 |
| Silica | 0.65 |
| Oxide of iron | 0.23 |

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| | | |
|---|---|---|
| Chlorine | 0.22 | |
| Carbonic acid | 2.88 | |
| Albuminoids | 230.20 | Containing ammonia, 44.61 |
| Cellulose | 50.30 | |
| Fat | 13.70 | |
| Carbohydrates | 480.70 | |
| | 1,000.00 | |

*Sample of Cow Pea Vines (a Mixture of Black and Yellow, about equal parts of each).*

| | Per ct. | |
|---|---|---|
| Water | 72.81 | |
| Ash | 2.00 | Per ct. |
| Albuminoids | 1.85 | Containing ammonia, 0.35 |
| Cellulose | 15.27 | |
| Fat | 0.21 | |
| Carbohydrates | 7.86 | |
| | 100.00 | |

WATER-FREE SUBSTANCE.

| | Per ct. | |
|---|---|---|
| Ash | 7.37 | Per ct. |
| Albuminoids | 6.81 | Containing ammonia, 1.32 |
| Cellulose | 56.27 | |
| Fat | 0.78 | |
| Carbohydrates | 28.88 | |
| | 100.00 | |

*The Ash of Vines.*

| | Per ct. |
|---|---|
| Ash | 2.00 |
| Potash | 14.80 |
| Soda | 23.29 |
| Magnesia | 6.74 |
| Lime | 22.57 |
| Phosphoric acid | 9.28 |
| Sulphuric acid | 2.35 |
| Silica | 1.08 |
| Chlorine | 0.19 |
| Oxide of iron | |
| Carbonic acid | 19.70 |
| | 100.00 |

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*The Ash with Silica and Carbonic Acid deducted.*

| | *Per ct.* |
|---|---|
| Potash | 18.68 |
| Soda | 29.40 |
| Magnesia | 8.51 |
| Lime | 28.49 |
| Phosphoric acid | 11.71 |
| Sulphuric acid | 2.97 |
| Chlorine | 0.24 |
| | 100.00 |

One thousand pounds of the fresh vines will contain as follows:

| | *Lbs.* | |
|---|---|---|
| Water | 728.10 | |
| Potash | 2.96 | |
| Soda | 4.66 | |
| Magnesia | 1.35 | |
| Lime | 4.51 | |
| Phosphoric acid | 1.86 | |
| Sulphuric acid | 0.47 | |
| Silica | 0.21 | |
| Oxide of iron | | |
| Chlorine | 0.04 | |
| Carbonic acid | 3.94 | *Lbs.* |
| Albuminoids | 18.50 | Containing ammonia, 3.56 |
| Cellulose | 152.70 | |
| Fat | 2.10 | |
| Carbohydrates | 78.60 | |
| | 1,000.00 | |

The value of the cow pea as an article of food, and of the vines for feeding and fertilizing purposes, will best be shown by a comparison with seeds and grains of well known standard qualities.

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TABLE I,

Showing comparative composition of certain grains and seeds calculated to *water-free substances* for uniformity:

| | Ash. | Albuminoids. | Crude fibre. | Carbohydrates. | Fat. |
|---|---|---|---|---|---|
| Cow pea, black | 3.72 | 25.37 | 5.48 | 63.81 | 1.62 |
| Cow pea, yellow | 4.10 | 28.50 | 6.23 | 59.49 | 1.68 |
| Maize (corn) kernel | 1.66 | 12.76 | 2.53 | 77.37 | 5.68 |
| Field beans | 4.00 | 29.94 | 13.45 | 53.21 | 2.38 |
| Garden pease | 2.91 | 26.13 | 10.73 | 61.02 | 2.91 |
| Wheat | 2.33 | 15 18 | 3.50 | 78.97 | 0.58 |
| Acorns | 2.21 | 4.54 | 10.20 | 82.95 | 5.22 |

COMPARATIVE NUTRITIVE VALUES.

Chemical science has not only been able to devise means of determining the composition of agricultural products, but in the case of feeding stuffs can also determine their comparative nutritive values. Space will not allow an explanation of the means of reaching these results. Suffice it to say, that in Europe feeding stuffs are sold by analysis, and their values are determined by analysis. The system has been successfully defended by Wolff and others. Without further discussion of the methods, I will apply the table of comparative value to the above seven substances. It may be said though, in brief, that the albuminoids form readily the blood, tissues, muscles, membranes, cords, &c., of the animal structure. and may be called flesh formers. The carbohydrates (including fibre) are the fuel which keep up the heat and combustion necessary to keep the animal machinery running. They may therefore be called heat producers. The fats have,

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as is generally believed, about the same office as the heat producers, though in a somewhat greater (more available) degree. While the albuminoids build up and constantly keep in repair the living machine, the carbohydrates furnish the power which runs it.

The technical term "nutritive ratio" merely means the ratio existing in any article of food between the per-centage of albuminoids and carbohydrates, including fat and fibre. Thus, if a sample of grain contains

| | |
|---|---|
| Albuminoids, . . . . . | 3.375 per cent. |
| Carbohydrates+fat+fibre . . . . | 38.594 " |

we have $\frac{38.594}{3.375}=11.43$, which makes the nutritive ratio of the sample 1 to 11.4 (1 : 11.4). In this way we find the nutritive ratio of our table given above to be

| | |
|---|---|
| Cow pea, black, . . . . . | 1 : 2.80 |
| Cow pea, yellow, . . . . . | 1 : 2.36 |
| Maize (corn) kernel, . . . . . | 1 : 6.70 |
| Field beans, . . . . . | 1 : 2.30 |
| Garden pease, . . . . . | 1 : 2.85 |
| Wheat, . . . . . | 1 : 5.47 |
| Acorns, . . . . . | 1 : 21.66 |

From this comparison we can readily locate the cow pea in its proper place as a feeding stuff. Taking the nutritive ratio of the bean as the unit, the other substances will come in the following order: 1, the field bean; 2, yellow cow pea; 3, black cow pea; 4, garden (English) pea; 5, wheat; 6, maize; 7, acorn. The garden pea and the bean being the most nutritious vegetables, weight for weight, we see how near the cow pea approaches to these as a food for man or beast, and how high it stands in the scale of value. A more exact and extended comparison would exceed the limits of this chapter.



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TABLE II,

Showing comparative composition of certain grasses and other plants, calculated to water-free substance:

| | Ash. | Albuminoids. | Carbohydrates. | Crude fibre. | Fat. |
|---|---|---|---|---|---|
| Cow-pea vines | 7.37 | 6.81 | 28.88 | 56.16 | 0.78 |
| Red clover (ripe) | 1.97 | 4.31 | 10.03 | 9.33 | 0.93 |
| Timothy | 5.25 | 10.15 | 56.94 | 2.64 | 3.50 |
| Maize (corn) fodder | 1.28 | 1.28 | 12.71 | 5.48 | 0.58 |

Proceeding with this table as before, we find that the nutritive ratios are as follows:

Cow pea vine, . . . . . 1:12.60
Red clover (ripe), . . . . . 1: 4.70
Timothy, . . . . . 1: 6.21
Maize (corn) fodder, . . . . . 1:14.66

Arranging these substances in order with clover at the head, we see that the cow pea vine stands third as a fodder material. 1, red clover; 2, timothy; 3, cow pea vines; 4, corn-fodder.

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TABLE III,

Showing the comparative fertilizing value of the cow-pea vines from composition of 1,000 lbs., water-free substance:

| | Potash. | Soda. | Magnesia. | Lime. | Phosphoric acid. | Sulphuric acid. | Silica. | Chlorine. | Ammonia. |
|---|---|---|---|---|---|---|---|---|---|
| Cow-pea vines..... | 10.88 | 17.13 | 4.96 | 16.58 | 6.84 | 1.68 | 0.77 | 0.14 | 13.20 |
| Red clover (ripe).... | 23.21 | 1.07 | 8.21 | 22.85 | 6.66 | 2.02 | 1.78 | 2.50 | 32.60 |
| Golden millet..... | 26.87 | ..... | 5.93 | 7.81 | 4.06 | 2.50 | 20.93 | 4.68 | 33.10 |

One thing will be noticed at once on examining this table, the high per-centage of soda. This will be accounted for when we remember the character of the soil upon which the vines grew. It was charged with soda-salts, and deficient in potash. Soda and potash being often interchangeable in the composition of plants, we can well believe that the cow-pea vines, grown upon a soil heavier than that at Chapel Hill, containing much potash, would show a decrease in soda-salts, and a proportionate increase in potash. We notice that in phosphoric acid the vine exceeds both clover and millet.

These analyses, with one exception, were made in duplicate. The determinations of cellulose, fat, and albuminoids are the average of from three to five different determinations.

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# THE "BURTON AIL."

BY THE SECRETARY.

The secretary of the board in his reports, and in papers prepared for publication in public journals, has often made reference to a disease among neat stock in the town of Albany, in Carroll county, formerly called "Burton." The disease was named for the town for the reason that it is more manifest there than elsewhere, though it is not limited by town lines, but prevails in sections of neighboring towns, and now and then at a distance where the soil and soil-products are similar to those in Albany.

The secretary has visited the locality of the disease in Carroll county, and has examined the animals affected by it. They are not attacked suddenly, but indicate the presence of the affection by a rough coat, slight at first, which in a short time stands at right angles to the body, or turns towards the head.

During this time the animal has a dull appearance of the eye, and becomes very costive, as named by Professor Dana. At this stage, if removed to a locality of good soil and vigorous vegetation, the animal undergoes a favorable change, and in time recovers. The farmers are in the habit of exchanging cattle so as to remedy the evil.

In 1822, Prof. Dana, of Dartmouth college, was appointed by the state medical society to visit the locality and make an examination of the disease and its causes. He made a report, which we copy in full as a curiosity, as well as for the purpose of showing the entire misapprehension under which Dr. Dana labored.

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## DISEASE OF CATTLE.

*Report on a disease afflicting neat cattle in Burton (N. H.), read before the New Hampshire Medical Society, June, 1822, by James F. Dana, M. D., professor of chemistry, mineralogy, &c., Dartmouth college.*

At the last meeting of the society I had the honor to be appointed to visit the town of Burton, in this state, and inquire into the causes of a disease to which neat cattle are there subjected; and I have now the pleasure of submitting to the society the result of the observations which have been made in consequence of this appointment.

That part of the town in which the disease is most prevalent is surrounded by lofty hills and mountains, the highest part of which is a very elevated point called Corway-peak mount, and is visible from a great extent of country. The predominant rock of which these hills are composed is granite, a soft decomposing variety in which the crystals and grains of feldspar are very large, and are suffering a rapid decomposition, by which the whole is disintegrated and broken down. The loose stones consist principally of rolled masses of granite, quartz, feldspar, and some specimens of hornstone; a bed of bog ore of iron is also found here. The soil of this place is fertile, and is such as we should expect to be produced by the decomposition and disintegration of granite rocks, viz., a sandy loam mixed occasionally with coarse gravel. No peculiar appearances were noticed in the vegetation. The usual crops raised by the farmer grow in Burton as in other places, under a similar culture and management, and probably the town would be a flourishing agricultural place if neat cattle could be kept and raised there. The fact is sufficiently established, that young neat cattle cannot be raised there, and that cows and oxen cannot be kept there for a number of years without being afflicted with a singular and fatal disease; and it is not a little remarkable that horses and swine have never been attacked by the complaint. Cattle are more liable to the disease at some seasons of the year than at others, and are usually attacked by it at the close of winter. The symptom which marks its commencement and progress is a loss

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of appetite;—the animals refuse hay, grain, and salt; they become feeble and much emaciated, and obstinate costiveness accompanies the disease, but the abdomen becomes smaller than in health; the abdominal muscles are contracted towards the spine, and the whole abdomen is diminished to one third of its original bulk. After these symptoms have continued an indefinite time, a brisk scouring comes on, and the animals fall away and die. For this complaint, which is very general among those cattle which have remained two or three years in the place, no remedy has been used by the inhabitants with marked benefit and uniform success; the cattle recover only by driving them away to some other place. A satisfactory cause for the disease has not yet been ascertained, and consequently a rational mode of cure has never been adopted. Neglecting the romantic and idle tale of the dying curse pronounced on this place by a murdered Indian, we are to search for the cause of the disease in the food which the cattle eat, or in the water which they drink.

The fact that cattle are seized with the disease late in the winter seems to point to the food as a source of the evil; and it is well known that certain plants have proved prejudicial and fatal to cattle. The *cicuta virosa*, or water hemlock, was found by Linnæus to be the cause of a disease afflicting the cattle in Norway; and here goats and swine were exempted from the disease. But this plant was not observed in Burton, nor was any other vegetable discovered here which does not grow in other places in the same latitude, and hence we do not believe that the disease is caused by the food. In confirmation of this opinion, I may adduce the fact that the hay produced in this place causes no disease in cattle which are kept on it in the neighboring towns; whereas hay which is brought from other places into Burton does not appear to prevent the complaint.

It has been sarcastically suggested that cattle died at Burton because there was not a sufficient quantity of hay produced there to keep them, but this suggestion appears to be as unjust as it is ungenerous. Hay is produced in such quantities as to be more than sufficient for the cattle. The result of my inquiries on this subject is, that there is a sufficient quantity of hay produced there for the use of all the stock, but that it does not

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contain any vegetable substance which is prejudicial to the cattle, and which may be considered as a source of the disease.

The examination of the water from various places in Burton offers a more satisfactory result, but there are no external marks which indicate that the water is unhealthy. No sediment is found, no incrustations appear on the sides of the rivulets and springs, but, on the contrary, the water is clear,* transparent, and colorless, and of a pleasant taste. From such properties I despaired of detecting any substances in it by the application of chemical agents, but was happily disappointed on making the examination. A portion of the water from a brook, to which the cattle have free access, was first examined *Tincture of soap* produced cloudiness, *oxalate of ammonia* produced a slight cloudiness, and *nitrate of silver* produced a similar effect. No change occurred on the addition of *Barytic water*, solution of *prussiate of potash*, or *tincture of galls*, or of *turmeric*. It follows from the action of these agents that the brook water, unlike the water of most brooks, is a hard water and contains some saline body. From the action of oxalate of ammonia, we infer the existence of lime, and nitrate of silver proves the existence of *muriatic acid;* the water is, then, a weak solution of muriate of lime. Having ascertained the existence of minute portions of muriate of lime in brook water, an examination was made of the water procured from other sources; and water from eleven other places, remote from each other and from the brook above mentioned, was examined, and the same effect was produced by the same agents. The effect was more perceptible in some instances than in others, and usually greater in water from wells than in that from other sources. The water from two wells in particular afforded abundant precipitates with the oxalate of ammonia and nitrate of silver. The only beast laboring under the disease while I was at Burton drank daily from one of these wells.

The continued use of a weak and very dilute solution of muriate of lime may, from its known properties, produce the effect now ascribed to it, and be the cause of the disease. Muriate of lime, it is well known, is employed as a medicine, and, like other

* It is a common remark, that the waters of Burton are remarkably clear. Probably their refractive density is increased by the saline matter they contain.

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saline medicine, acts more powerfully on the general system in small doses largely diluted, than in greater quantities and in a more concentrated state. In some diseases of the glands it is said to have been employed with advantage, and when first administered improves the appetite and general strength. The latter effect is very evidently produced on cattle when first pastured in this town. If previously thin and emaciated, they speedily become fat, and appear better than cattle ordinarily do during the first season they are pastured in Burton.

It may with propriety be asked why horses and hogs escape the disease, if it is produced by the water. A satisfactory answer is derived from the fact that horses are not suffered to remain a long time at home; they are continually absent on journeys, and probably in most instances take as much water from other sources as they do from the wells and springs on the farms to which they belong. Hogs take but small quantities of water, and, from the mixed and heterogeneous kinds of food given to them, they must frequently take such saline substances as will counteract the effects produced by the minute portions of *muriate of lime*.

If the disease arises, as is supposed, from the saline contents of the water, we can easily explain the fact that its attacks are most frequent in the winter. It is then that they usually receive water from wells, which are proved by experiment to be most strongly impregnated; and then also springs are generally low, and consequently contain more saline matter: nor does the food in winter tend to counteract the effect of the water by keeping the bowels lax, which is a well known effect produced by summer and spring food.

The disease, to which the cattle in Burton are thus subjected, has been a great obstacle to the prosperity of the town, and it will probably continue to have this effect, although without doubt it may be prevented by proper attention and management. Some persons residing in Burton have for several years past given to their cattle, during the winter season, a certain kind of mud, and, as they affirm, with some benefit. This mud is found on a meadow, and during the summer it is collected for use. It is made into balls as large as an ordinary potato, and forced down the animal's throat. By it the tonic effect of the muriate

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of lime is prevented, and the bowels are kept lax. I visited the spot where the mud is procured. A spring issues from the place, and the water brings with it a greyish white matter which is deposited in the rill leading from the spring. This whitish substance is the matter in question. After being heated to redness it becomes snow white; when digested in an acid, a slight effervescence occurs, a portion is dissolved, and the remainder has the character of fine, white silicious sand. The portion dissolved in the acid was found by appropriate tests to be *carbonate of lime*. The effect of this substance cannot be explained on chemical principles, and doubtless depends on the general principles of the effect of laxatives in counteracting the actions of tonics.

Having embraced the idea that this disease arises from the small portion of muriate of lime dissolved in the water, I recommended to a number of the inhabitants, who were assembled for the purpose of assisting me in my inquiries, to make use of weak lye, or ashes, or soap suds, as a remedy, or rather as preventives. Either of these substances, from the carbonate of potash they contain, will decompose the muriate of lime, and carbonate of lime and muriate of potash will result from such decomposition. Now both these substances, if not quite inert in the small quantities in which they would be produced, will act as purgatives, and as a confirmation of the general principles advanced in this paper. I was informed, on recommending soap suds, that the only cow which was ever raised in Burton and escaped the disease was in the habit of frequently drinking soap suds from the tubs which contained it, and that it was consequently left for her use after family washings. It is not a little remarkable that the inhabitants did not avail themselves of the information to be derived from this hint.

A person who formerly lived in Burton brought water from a spring situated at a distance from his house for the use of his cattle, and they were found to thrive much more, and with greater certainty to escape the disease. Why he was induced to use this water I know not, but on examination by re-agents it gave indications of containing very small quantities of muriate of lime—much less quantity, indeed, than in any other water submitted to examination.

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These facts and observations are now submitted to the society, with the hope that the investigation, conducted under their auspices, may not prove wholly uninteresting and useless.

COMMENTS.

We believe the professor did not reach the cause of the disease, and that it should be attributed, as it now generally is, to the absence of phosphoric acid in the vegetable productions on which the cattle are fed.

The evidence of our position may be found in the facts given by Dr. Dana. For example, he says "the disease prevails mostly towards spring." This is in consequence of the innutritious hay on which the animals have been fed through the winter, particularly the "white-top" hay, or what is erroneously called "June grass,"—the botanical name being *danthonia specata*. A chemical examination shows it to contain potash, but very little phosphoric acid.

He says a certain mud, which from his description contains phosphoric acid, will prove an antidote. The cattle there are prone to gnaw bones, and we are told will eat greedily of chemical fertilizers containing from ten to fifteen per cent. of phosphoric acid. In this, we think, is the grand mistake of the professor. He does not admit the food, that is, the hay, to be different from that in surrounding towns. Had he submitted the grass or hay to an analysis, he would have discovered the difference.

With propriety he inquires why horses and swine are not affected, and gives the answer, that horses get much of their drink on the road, and swine don't drink much. We say, swine don't eat the poor hay, and horses are fed with the coarser kinds, like herd's-grass and clover, and eat oats, which in themselves are a remedy. His argument tells in favor of our theory and against his own, when rightly applied. "It does not contain any vegetable substance prejudicial to cattle," says the report, but it lacks a mineral element very beneficial and absolutely essential to the health of cattle.

The professor recommends lye from ashes. We say, give the animals ground bone, bone-meal, and hay containing a liberal proportion of phosphoric acid.

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Our opinion is confirmed by this fact. A few years ago the board of agriculture was notified of a fatal disease prevailing on a certain farm in the town of Temple. Dr. Mason and the secretary visited the location, saw a cow, greatly emaciated, with staring coat, glassy eyes, and tottering gait, which was a specimen of those that had died. The sources of water were examined; the lay of the land, a northern slope, was considered; also the fact that it had been long cropped. The hay from which the cattle were fed was the fine, leafless "white-top," already named.

The symptoms of the disease were studied. It was evident that the hay was not only insufficient for the demands of the animals, but that it actually caused an irritation and finally an inflammation of the stomach.

The animal was slaughtered, and the result of the examination proved the theory of Dr. Mason to be correct. We subsequently learned that measures adopted to correct the deficiency in the feed proved to be the adequate remedy. Poor soils, unmanured for a long series of years, produce gases so destitute of the elements necessary to full nutrition that animals fed upon them will die slowly but surely. Too much of our upland hay is produced on rocky hill-sides from which phosphoric acid has been removed.

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# FINE-WOOLLED SHEEP HUSBANDRY.

BY HENRY F. PEARSON.

This branch of agricultural industry, whose age is but a little more than sixty years, has been within that time one of the most, if not the most, profitable in which the farmers of New Hampshire have engaged.

The fact that this industry is falling into disrepute; that capital is being withdrawn from it; that farms once well stocked with sheep, and paying handsome profits to the owners or occupants, are being deserted; and that while this industry is falling off no other has taken its place,—calls for a careful consideration of the subject with the view of finding the cause and a remedy.

This industry had its start at the importation of Spanish merino sheep, and the manufacture of cloth from the wool, and the use of the fat ones for food. Under laws for the protection of the wool and the goods of this class great progress was made. But conflicting interests coming up, changes were made in the laws controlling the duties on wool, embarrassment overtook the wool-grower, and low prices are the result.

Again: There comes a conflict between the grower and manufacturers, and the interests of the two are at variance. We have in New England a class of sheep-breeders who make this their basis of action. If the manufacturers will pay us no more for light, clean wool than for heavy fleeces of grease and dirt, we will give them heavy fleeces. This principle carried out has produced the heavy wool of Vermont and New Hampshire, which now goes into market with its own reputation. Other sections of the country produce cheap, low-priced wool. Upon this basis, our production of a common, low-priced wool, and competition with wool from the territories, are out of the question.

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By the effort to produce the heavy fleeces, the mutton qualities of our fine-woolled sheep have been seriously impaired, so that while the original merinos were the best of feeders, and the quality of the mutton was equal to the best in our market, the new style, so called, improved merino is avoided, both by the feeder and the butcher.

Is it, then, a matter of disappointment to one investigating the subject, that in a time like this, when low prices are the rule, when we find our fine wool commanding the lowest price, our fine woolled-sheep of poor quality for mutton, the cost of production greater here than in other parts of our country with which we must compete, he finds the industry must die out and be a failure if conducted on the present basis? But before giving up, let us look at certain means that may be used to restore it to a profitable basis.

We have shown that at the time when by heavy fleeces the price of wool went down, and it became neglected in market even at a low price, the mutton qualities of the sheep were injured. We therefore conclude that the way to success is to return to the old basis, namely, a better quality and lighter fleece, and consequently a better mutton sheep.

It is a fact of history, that New Hampshire has competed successfully with the world in the production of the finest wool; and it is a fact that under a system appropriate to and in harmony with our methods of agriculture, a high priced quality of wool can be raised, which will only come in competition with like systems in the older states from the fact that the wool from the plains cannot compare with it. But the effort of some in our midst to mix in one sheep characteristics of the coarse-woolled breeds, without any basis of uniformity or evenness of fleece, is a great mistake. The wool comes into market, and is of the same quality and the same price as the heterogeneous mass that comes from the plains, and now commands but a few cents per pound. Competition on this basis is out of the question.

But I would take as the standard fine-woolled sheep which will produce fleeces as above which will weigh from five to seven pounds, and at the present price—which is the lowest for twenty-five years—commands from thirty-three to thirty-seven cents per pound, and at the same time grow carcasses whose

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mature weight shall be from ninety to one hundred and fifty pounds each, and produce lambs from sixty to ninety pounds' weight. This can be easily attained; and it requires but little calculation to see that a sheep of this class can be kept at a profit by New Hampshire farmers who wish to go into this branch of work on a large scale; for this is one of the best features of fine-woolled sheep husbandry, that they thrive well in large flocks. To this feature I wish to call special attention. Our farmers must have large flocks; for, give them a good range in summer, they care for themselves and give the owner but little work, while with the improved methods and machinery for farm work the farmer or sheep husbandman can produce upon his tillage land, at a given cost in labor, enough more in quantity to winter such an increased number of sheep as shall make the net income from them equal to the same under old methods, with the selling price of wool what it is upon the average under the present system of protection.

Then there must be new modes of management to meet the demands of the times as to the time and manner of shearing. A method adopted by some is to shear their sheep about the first of April,—and, contrary to a general impression, ewes which are about to drop lambs do better then than at any other time; for being in good condition, as they always should be at this season, they endure the change as well or better than at other times, and pass through the close confinement and warm quarters of lambing-time free from the incumbrance of the wool upon themselves or in the way of the lamb.

Taking off the fleece gives an increased appetite; and this comes just at the time when under other conditions it would fail. Another reason why shearing should be done at this time is this, that when ewes drop lambs early, with the fleece upon them, the change in condition destroys in a measure the growth of wool, so that, deferring the shearing a month or two, a quantity of the wool drops off and is lost, and the remainder has a weak section, thus decreasing the real value to the manufacturers.

This process I would apply to the breeding ewes wholly, except where the pastures are so near to the barns that the common store sheep can be protected from the early spring rains

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and cold,—for this class do much better running at large as soon as warm weather comes and grass begins to grow, than when confined at the barns. If they are not sheared when the others are, let them run until warm weather is a settled thing: a few days' protection makes them safe from injury by storms.

It may remain a matter of choice whether the sheep are washed or not previous to shearing, as on an equitable sale of the wool the income will be the same.

This paper will not be complete without giving the probable income and standing of a flock of 250 sheep for one year of the class I have before described. We will consider the flock as all store sheep, without any for fattening.

| | |
|---|---|
| 100 breeding ewes, value, | $300.00 |
| 90 lambs, $2.25 each, value, | 202.00 |
| 60 wethers, $2.50 each, value, | 150.00 |
| | $652.00 |

ESTIMATED COST OF FLOCK.

| | |
|---|---|
| Keeping breeding ewes entire year, | $225.00 |
| Keeping 90 lambs or yearlings, | 157.50 |
| Keeping 60 wethers, | 105.00 |
| Taxes on money invested, | 10.00 |
| Interest on money invested, | 37.50 |
| Expense of shearing 250 sheep, | 12.50 |
| Cost of sheep and their keeping, | $1,199.50 |

INCOME FROM THE SAME.

| | |
|---|---|
| 250 fleeces at 6 pounds each, 35 cents per pound, | $525.00 |
| 90 lambs, | 202.50 |
| Increased value of 90 yearlings, | 225.00 |
| " " 60 wethers, | 180.00 |
| " " breeding ewes, | 275.00 |
| Value of flock and income per year, | $1,407.50 |
| Deducting first cost, | 1,199.50 |
| Net profit, | $206.00 |

An additional item of income might be added, namely, that thirty of the wethers, instead of being sold at end of year at

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the price before named, could be stall fed, and the average gain in value in good hands is $3 each, amounting to $90: $60 of this sum would be the cash value of hay and grain consumed, and $30 would be profit.

According to the foregoing figures, we find an income from the store sheep and stall fed, $844.50 toward paying for help and interest on money invested in real estate. Now good authorities say $1,000 will buy a pasture which will support the sheep. Add to this $30 as cost of fencing and care, and we have $90 as summer cost of keeping. Deducting the same from amount, we have $754.50 for winter care. Allowing $100 for grain, and we have $654.50 for hay. Estimating five sheep to consume a ton, it will require fifty tons of hay, this giving $13.09 per ton—a better price than the average when sold for cash at the barns situated at a distance from market.

There is another advantage from sheep husbandry: the fertilizing quality of their manure is not surpassed by that of any other animal kept upon the farm. Now, it will be noticed that I have not taken fancy prices upon any part of this estimate; but let fancy prices be obtained in any direction, and the per cent. profit will be greatly increased. It is a question whether the same amount can be obtained with an equal cost in labor from any other stock upon farms situated at a distance from market, unless fancy or uncertain prices are obtained in some direction.

I well know that some points of my paper may be called in question. Those interested in the present fashionable fine-woolled sheep will question the amount of wool and the price of it, and the size of sheep and their growth in value. We had in our state a class of merino sheep, which, under the best treatment previous to the introduction of the excessively heavy fleeced sheep, would produce returns beyond those given, and we have the same class preserved to the present time. There is in other states a corresponding class which has been preserved in its integrity, and is able there to show better figures than I have given. Now it is to this class that I look for the production of wool and mutton, each of a quality to command the best prices in our markets, and thus restore this industry to its original standing even in New Hampshire.



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# THE POTATO-ROT FUNGUS.*

BY PROF. C. H. FERNALD, OF THE MAINE AGRICULTURAL COLLEGE.

The potato-rot has probably been the cause of greater destruction to the potato crops of the world than all other agencies combined. Even the injury caused by the Colorado potato beetle is but slight, when compared with that caused by the rot in years past.

The potato itself is a native of South America, found wild in abundance in the mountainous regions of Chili and Peru, and the rot occurred there even before its appearance in other parts of the world; in fact, South America, the home of the potato, is also, without doubt, the home and centre from which has been distributed the minute fungus which has caused such destruction to the potato crops in all quarters of the globe wherever it has been cultivated.

The disease first made its appearance with certainty in Belgium in 1842, and in Canada in 1844, and also on the island of St. Helena in the same year. In 1845 it spread with alarming rapidity through Europe and the United States, at least the northern parts. During the following four or five years it was distributed over the world, wherever potatoes were cultivated, causing most distressing results among those people who depended largely upon their potato crops for support. During these years the destruction of the potato crop by the rot caused in Ireland one of the most dreadful famines known in the annals of history, and it has been estimated that more than a million persons died from starvation in that country.

* Read at the Maine Pomological Society, and printed in the report of the Board of Agriculture for 1882.

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### SUPPOSED CAUSE.

Many theories were advanced to account for and explain the remarkable phenomenon, as it was regarded. Some claimed that the cause of the rot was a peculiar fungus, but what its nature was they did not seem to have the slightest conception. Others supposed it to be caused by insects, but by what kind and in what manner it was not made clear. Still others declared that it went in the air, but without the slightest knowledge of the manner by which the air becomes the vehicle for the transportation of contagion of any kind; and finally there were those who believed that it was a dispensation of Divine Providence, sent upon the people as a punishment for their sins.

### THE TRUE CAUSE.

Immediately upon the outbreak of the potato-rot in Europe, investigations were made by careful scientific men, who discovered that the diseased plants were more or less infected by an unmistakable fungus, the minute thread-like mycelium of which penetrated in all directions through the tissues of the leaves, stems, roots, and tubes; that through the stomats or breathing pores, on the underside of the leaves, the fruiting portions of the fungus extended out into the air, and that through the corroding influence of the mycelium the tissues were changed into the well known condition of the potatoes when attacked by the malady. Dr. Montagne first described the fungus under the name of *Botrytis infestans*. About the same time it was described by Madame Libert under the name of *Botrytis devastatrix*, and by M. Desmazieres under the name of *Botrytis fallax*, but Dr. Montagne's name being the oldest in point of time is the one now adopted; but in a revision of the genera this species has been placed in a new genus, and the fungus is now known by the name of *Peronospora infestans*, Mont.

For a long time it was hotly disputed that the fungus was the cause of the potato-rot. Some contended that it only lived in and fed upon the fermenting and decomposing tissues of the potato, but experiments conducted by DeBary, of Strasburg, and others, have fully established the fact that this fungus is the real and true cause of the potato-rot. Before we can hope

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to subdue an enemy, it is necessary to know its structure and habits, and then we may possibly find some vulnerable point where it may be attacked with some degree of success.

### NATURAL HISTORY OF THE FUNGUS.

Like other fungi this species has a vegetating and a fruiting portion, which includes several kinds of seeds or *spores*, as they are called. The vegetating portion is represented by long, slim, branching threads, called the *mycelium*, which penetrate throughout the tissues of the potato plant, absorbing its nourishment from the cells of which those tissues are composed, causing them to decompose, and the whole substance to become a foul and fœtid mass.

To understand the position which the fungus occupies in a potato leaf, let us examine the normal structure of the leaf. If we make a vertical section through the leaf of a potato, and examine it under a moderately high power of the microscope, we see that the upper and lower surfaces are each covered with a single layer of colorless cells, forming what is called the *epidermis* of the leaf, and from the surface of the under side arise those hair-like bodies which give to it the peculiar hairy appearance readily seen by the naked eye. Besides the hairs on the under side of the leaf there are minute openings through the epidermis, called breathing pores or stomats, which are guarded by peculiarly formed cells which open or close the breathing pores according as the air is moist or dry, thus regulating the evaporation from the leaf. The interior of the leaf, between the epidermis of the upper and lower surfaces, is composed of a mass of cells of a more or less globular form, according as they are more or less crowded and compressed into other than the normal globular form. The first layers of these cells immediately beneath the epidermis of the upper side of the leaf are more compactly placed than those below, and form a denser tissue on the upper than on the lower surface of the leaf, and they do not permit so free a circulation of the air. These cells contain in their protoplasm a mass of granular matter of a bright green color, called *chlorophyl*, and here is where the food of the plant is elaborated. There are also bundles of woody tissue scattered here and there through this part of the leaf, forming the veins

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and veinlets. Through this portion of the leaf the fungus pushes its mycelium in long fine threads between the green cells of the leaf, and contrasts in color with the green cells in being of a light brown color, though of a much smaller diameter than the cells themselves. As the mycelium rests against the side of a cell, it gives off, occasionally, little projections called *haustoria*, which press upon the side of the cell, or even penetrate into it, by means of which the mycelium draws its nourishment from the cell, which becomes more and more exhausted, and at last is completely destroyed.

After the fungus has developed to a certain extent, branches are given off which extend out into the air through the breathing pores, and occasionally through the epidermis, even of the upper surface. When these branches have reached beyond the surface of the leaf they form several branches, at the ends of which are developed egg-shaped bodies, which burst open at maturity, and from them escape from six to fifteen very minute and peculiar bodies of an ovoid form, with two long thread-like organs by means of which they propel themselves through the water, after the manner of certain microscopic animals; in fact, so closely do they resemble animals in their movements that they have been called *zoospores*, from a Greek word meaning animal and spore. After these zoospores have moved about in the dew or water which may be held by the hairs on the under side of the potato leaf, and which would form an ocean for these minute bodies, they make their way into the interior of the leaf again through the breathing pores. In about half an hour from the time they are first discharged they come to rest, the thread-like organs of locomotion disappear, and the zoospore at once elongates into thread-like mycelium, like that from which it originated. The egg-shaped bodies do not always burst and give rise to zoospores, but sometimes fall off and develop at once into mycelial threads; and if by any chance they fall near or upon the potato plant, this mycelium corrodes and pushes its way into the interior of the plant to continue the same round of life as before.

It has been calculated that one square inch of the under surface of a potato leaf may yield 3,000,000 zoospores, and that in an incredibly short time these will have grown and developed a new generation, so that it is not at all surprising that after the

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first appearance of the disease an entire field of potatoes is so quickly destroyed.

There is still another kind of spore called *conidia*, which are formed on certain of the branches which grow out through the breathing pores into the air. These are of a globular form, and much smaller than the others, and they develop into mycelium after they fall off in precisely the same manner as the zoospores after they come to rest. So small are these conidia that the slightest breath of wind can waft them across the field, and they may be carried from field to field by only a moderate breeze, so that one infested potato field may be the means of infecting those for miles in the direction the wind happens to be blowing. It is a noteworthy fact that this parasite on the potato thrives best in a warm, damp spell of weather—in fact, without moisture it does not seem to thrive at all—so that it has been regarded as a water plant, and so located by the botanists.

This much of the history of the potato-rot fungus has been known since the investigations of DeBary in 1863. As this disease of the potato makes its appearance in midsummer, and runs its course on the tops in a field of potatoes in a few days or a week, and as the spores and mycelium thus far described are destroyed by the frosts of winter, the question arises, How does the fungus continue, or what is the natural state of the fungus during all the rest of the year?

There have already been described some eighteen different species of the genus *Peronospora*, six or seven of which have been observed in this country. Now the complete round of life of quite a number of these species has been clearly made out and is well known. They are multiplied not only by spores like those already described, the conidia and zoospores, but there was also found, entirely within the tissues of the host plant, another kind of a spore which formed a dense, hard, rough outer coating sufficient to protect it from the frosts of winter, and this was called the *oospore*, or resting spore, because it was the stage in which the parasite rested from its activity during so great a portion of the year. Analogy led us to suppose that there must be a resting spore formed somewhere, which would preserve the life of the potato-rot fungus during its long period of inactivity, and protect it during the freezing cold of winter. For years

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botanists had been searching for this resting spore, well knowing that until it was discovered all attempts to hold the pest in check were just as likely to favor the continuance of the fungus as to destroy it. It is true that Dr. Montagne, in 1844, found some peculiar bodies in rotten potatoes which Mr. Berkley claimed were the resting spores; but though searched for again and again, no one was able to find anything like them, and it came to be doubted whether the bodies described by Dr. Montagne, under the name of *Artotrogus hydnosporus*, Mont., had any connection whatever with the potato-rot fungus. It was also well known that certain species of minute parasitic fungi pass one stage of their existence on one species of plant, and another on a totally different species, as the too common rust of wheat which passes one stage on the Barberry and another on some species of the grass family.

The so called lettuce mold (*Peronospora gangliformis*, Berk.) a species closely related to the potato-rot fungus, was known to develop in the tissues of lettuce and form conidia and zoospores on that plant, but it also infested the common sow-thistle, chiccory, and some other plants, and in the tissues of these last were formed the resting spores which were able to continue the existence of the parasite through the cold winter months, when it again attacked the lettuce. Other species of *Peronospora* are confined to a single host plant. From all this knowledge of other species, botanists were quite in doubt where or when to look for the resting spores of *Peronospora infestans*, Mont. The leaves and tubers of diseased plants were examined again and again without success, and the suspicion began to prevail that clover might be the plant within which the resting spores were formed, and many farmers were inclined to regard the clover plant with suspicion, thinking that it might in some way be favorable to the potato disease, and even the stable manure from animals fed on clover hay was not used under potatoes. It was thought by some, and not without good reason, that the resting spores were not only able to retain their vitality in the tissues of the clover during the cold of winter, but also in their passage through the alimentary canal of the animals fed on the clover. Experiments in planting potatoes on newly plowed clover lands, and also on manure from clover fed animals, as

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often gave negative results as anything else, so that the farmers were totally in the dark, not knowing what to do, as often doing the very worst thing as the best, till at last it was impatiently asked, Why don't the scientists do something for us? The problem which they had asked to have solved was one of the most intricate and difficult which had ever been undertaken by the botanists. Not only was the most profound knowledge of the related fungi required, but also the most consummate skill in the use of the microscope and its accessories. The most extreme care is required in any attempt to cultivate these minute objects: a mere trifle too much of moisture may destroy them, or the merest breath of air which is too dry may cause the whole colony to collapse, and the labor of weeks be lost. Furthermore, the scientists were expected to do this work gratuitously. I am not aware that a single dollar was ever given by any government, state, or society to aid in the investigations on the potato fungus, with one single exception. The Royal Agricultural Society of England appropriated $500 to aid DeBary in his investigations on this plant.

In the early part of June, 1875, the editors of the London *Journal of Horticulture* called the attention of Mr. W. G. Smith, one of the foremost cryptogamic botanists in England, to what was then called "the new potato disease," which appeared in the form of small black spots over the surface of the leaves; but a microscopical examination proved that it was only the old enemy in a new guise, and appearing much earlier in the season than usual. Nevertheless, Mr. Smith called the attention of botanists, both in Europe and in this country, to the fact that the well known parasite had probably, under peculiar and unknown conditions, presented appearances quite different from what had hitherto been reported.

### DESCRIPTION OF THE RESTING SPORE.

In making an examination of the black spots on the potato leaves, Mr. Smith placed them with their edges in the water to mascerate them so that the interior of the leaf might be the more readily examined with its contained fungus; but in a few days it was found that the water greatly stimulated the growth of the fungus, and, before long, globular bodies appeared growing

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from the threads of mycelium within the tissues of the leaf. These globular bodies were not confined to the leaves, but were also found in the stems and in the tubers themselves. They were of two sizes,—one about the size of the cells of the leaf, and the other not more than one fourth as large in diameter. They were developed on small stems here and there from the mycelium, and when they happened to be near each other it was observed that they inclined towards each other until they touched, when a small tubular body called the *pollinodium* was extended out from the smaller body and thrust into the larger, through which more or less of the contents of the smaller was poured into the larger, which thus becoming fertilized developed into the long sought for resting spore of the potato-rot fungus.

The conidia and zoospores are not formed by the union of two elements, but multiply the species by what is called the asexual method of reproduction, while the resting spores—the result of the union of two unlike bodies—represent the sexual method.

When these resting spores have become mature, the stems upon which they were developed vanish and the spores are set free. After the potato plant has been badly attacked and destroyed by the fungus, every part of the plant and its parasite perishes excepting the dark brown resting spores just described, and these find their way into the earth and hibernate. When they awake to renewed life in the summer they must germinate in the damp earth, and if no potato plants are near they perish, as the earth cannot support them; but if potato plants happen to be near the corrosive mycelium, this penetrates at once into the roots or tubes and stems, and when they have extended into the parts above ground, as the stem and leaves, branches are sent out through the breathing pores into the air, and upon these are formed the conidia and zoospores which reënter the breathing pores and develop their mycelium within the tissues of the potato leaf, and the whole history of the fungus is repeated again.

It is a well known fact that the potato disease is most abundant in warm damp seasons. The summer of 1844 was unusually cloudy and moist; and, so far as I am able to learn, all the great outbursts of the disease occurred in seasons which were unusually moist and warm, especially if this condition prevailed in

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July and August. A short time only is quite sufficient for the development of the asexual spores and the complete destruction of the potatoes as we well know; and since the parasite is an interenal one there seems to be no good and practical method by means of which the malady may be arrested when once the potatoes are infested. If, however, the tops alone are affected, as would be the case when asexual spores are brought by the wind from some other infested field, we may save the potatoes in the ground to an extent by pulling up the tops before the mycelium has had time to penetrate down through the stems to the tubers. Even in this case great care should be used to prevent, so far as possible, the conidia and zoospores from falling upon the potato hills, since they have been known to be washed down through the ground far enough to reach the tubers and infest them. It is plain, therefore, that we should carefully burn all the infested tops, for should any of them fall into water, or into damp places even, the very conditions would be fulfilled which would cause the development of prodigious numbers of resting spores capable of infesting the crop of the following year.

It is an easy matter for us to conjecture how the resting spores may be so widely distributed as we know they must be. Should infested tops and tubers be allowed to remain in the field in damp places, or in damp weather, we can understand how the resting spores would be formed and matured. Later in the season, in September or October, the weather becoming dry, these tops would have decomposed, and the resting spores would be liberated and taken up by the winds and scattered over the fields, where they would hibernate, ready to attack the potatoes planted the next year in the ground where they had fallen.

From what we have learned of the life, history, and habits of the potato-rot fungus, we may safely say that it is better to plant *sound* potatoes only, on dry or well underdrained lands, where the conditions are the most unfavorable to the growth of the fungus; and then, if by any means the potatoes become infested, not only all the tops but all diseased tubers should be carefully burned, and potatoes planted the next year on a different part of the field. If all the farmers in a given region should pursue this course, it seems to me possible for them to hold the parasite in check.

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The course some farmers pursue is to put the potato tops into the compost heap. This is the most dangerous policy that could be adopted, if the manure is to be used under the next year's potato crop, for the dampness of the compost heap would give the most suitable conditions for the production of the resting spores. It is true that the tops put into a compost heap may not be infested with the fungus in question; but the risk is too great, and, as I believe, should be carefully avoided.

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## POTATO SCAB AND SKIN CRACK.

Prof. S. W. Johnson, of the Connecticut Agricultural Experiment Station, says,—

In a letter bearing date of Sept. 27th, Hon. Levi S. Wells, of New Britain, called the attention of the station to an affection of the potato, a disease of the surface of the tuber, resulting in a discolored and scabby appearance, and to some extent in deep cavities like worm-holes. Mr. Wells mentioned that for a number of years this disease has caused great loss to the farmers of this state, a large portion of the crop being in many instances rendered unmarketable. He sent three tubers which well represented the various stages of the malady. The following reply was made to Mr. Wells's communication:

The potatoes exhibit two kinds of disease, which have been studied by competent investigators in Germany, and what can be said here in regard to them is mainly derived from Dr. Hermann Schacht's "Report on the Potato Plant and its Diseases," made to the Prussian board of agriculture in 1854, and from Dr. Paul Sorauer's "Treatise on the Diseases of Plants," published in 1874.

The fairest of the three potatoes sent would ordinarily pass for a sound tuber, being diseased in but a few places. On its surface, however, are seen a multitude of skin cracks, or scars of skin cracks, mostly running lengthwise of the tuber. The larger number of these cracks have healed up by formation of new skin, leaving the tuber quite sound underneath. Some of the wider cracks, however, while externally healed, or dry at

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least, cover a discolored, moist mass of decayed tissue nearly half an inch deep. The rotten places are not due to the attacks of insects, so it has been decided from careful microscopic observation, but result from the skin cracks and the decay of the tissues and juices thereby exposed. Very probably insects or worms, getting lodgment in the cracks, hinder or prevent healing, while dampness of the soil and presence of decaying organic matters obviously would favor decay.

The cracks are attributed to a period of quick growth succeeding a time when the tuber was at a stand-still, and had begun to ripen off. When the tuber is young, and is supplied with material for growth from the foliage and roots (the tuber is itself a part of the stem), it gradually expands, and the cuticle enlarges by development of new tissue to accommodate the interior growth. If growth be checked after the tuber has advanced towards maturity, the skin shortly becomes firm in texture and less capable of yielding. Should rapid growth then recommence, the inner expansion must burst the skin. The cause of the cracks is thought to lie in the weather, or in the supplies of water and plant food as influenced by the weather. Drought checks the growth and tends to ripen. After drought, a moist growing time brings on the enlargement of the tuber and the cracking of its skin, and at the same time usually causes some of the eyes to grow: the sprouts either run a little way and then set to small potatoes, or more rarely reach the surface of the ground and throw out leaves and branches.

The second best potato sent, shows evidence of another disease, called scab or pock. This malady, though beginning differently from skin crack, affects the skin and results very similarly to that disease. On this tuber are seen but few skin cracks, but a great many little warts or pimply points of darker tint than the rest of the skin. These come from an abnormal growth of the cuticle. The skin, which when healthy is a layer of cork-cells of uniform thickness, at these points has begun to grow into the substance of the tuber, at the expense of the starch and starchy tissue underneath, very much as a corn on the foot appears to grow at the expense of the flesh. As the cork growth continues, the outer parts of the affected spot decay, and the decay follows down into the substance of the tuber. When these scabby tubers

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are dug and dried the decay ceases and the pock remains, a black or brown cavity separated by a rough layer of corky matter from the starchy tissue. This potato scab is thought to be connected with wetness of soil. The writer saw it years ago in northern New York, but never, to the best of his recollection, on mellow upland, or well drained soil.

If the causes of these affections are truly stated, the remedy must consist in improving the texture of the soil so that it shall duly regulate the water supply, and thereby the food supply, to the crops.

How do the facts as to the water-supply and circumstances of your crop the past season accord or disagree with the views herein expressed?

To this Mr. Wells answered,—"The drainage of the soil on which grew the potatoes I sent you cannot be improved. The soil is a gravelly loam, with a very clean gravel for a subsoil to the depth of twenty feet to water. The season has been very good, and every condition apparently favorably for the growth of the crop until maturity.

"I planted another plot of ground where the disease occasioned more loss. This was on high and dry ground,—the soil, sandy loam; the subsoil, sand (good plastering sand). On this field the rotation had been tobacco, corn, and potatoes. It had been well served each time with yard or stable manure.

"At harvest, the potato-rot as well as scab was quite prevalent. The cooking quality of the potatoes this season has been excellent."

Mr. Wells also says,—"I have observed that potatoes grown in northern New England very rarely show these defects, and when we fertilize with tobacco stalks, the crop is freer from them."

It should be noticed that while the soils of Mr. Wells's potato-fields have "perfect drainage," in a certain sense, they are in fact not circumstanced most favorably for a well regulated water supply to the crops they bear. A gravelly loam, with twenty feet of clean gravel intervening between it and bottom water, is liable to suffer from extremes of drought and wet. When heavy rains fall on such a soil, the surface loam becomes fully saturated with water, and this state of saturation continues for a

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considerable time. The porous gravel permits, indeed, the surplus of *flowing water* to run away in the depths, but the finely porous loam remains fully saturated with *capillary water* like a suspended lamp-wick upon which oil is poured from above, until it is completely drenched. If the bottom of such a wick be put in contact with a mass of cotton, the oil will be sucked into the latter, and the wick will be left with its pores lined with oil, but not full. So a loam resting on loam, *i. e.*, finely porous to the bottom water, will not remain saturated at the surface, but the rain that falls upon it will soak down to uniformly coat the particles and line the pores of the entire mass of soil.

The loam underlaid by gravel remains overcharged with water after copious rains to an extent and for a time that checks growth, it being proved by experiment that too much water is as injurious to vegetation as too little, a certain moderate supply being best for most cultivated plants. After heavy rains have saturated the soil, continued dry weather gradually removes the excess, the sun and wind evaporating it from the surface as a flame takes up the oil of a lamp, and the water from below rises in the porous earth as the oil ascends in the porous wick. In time the proportion of water becomes favorable to growth, but as dry weather continues, the stock of water in the soil underlaid with gravel may soon be reduced below the quantity best for crops, and drought may ensue because the gravel cannot raise the bottom water rapidly enough, whereas if the loam extended to bottom water, the latter would ascend and maintain the surface soil moist and supply the crop.

Perfect drainage implies a certain freedom of motion of the soil-water in all directions, that of flowing water through channels, that of capillary water through pores. Bottom water should drain upwards, through a sufficiently extensive and connected system of fine pores, to maintain the surface soil moist in drought, and surface water should drain downwards rapidly enough to prevent any prolonged capillary saturation of the surface soil.

It is a matter of experience among florists and gardeners, that slight surface wettings of the soil, whether that of pots, beds, or lawns, is of little or no use compared to an occasional thorough drench. During a long period of hot weather, with frequent

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light rains, but no heavy rain, the soil at the depth where the roots of a crop are mainly situated may easily become so dry as to check growth, when the surface soil and the sub-soil are both sufficiently moist. The evaporation of water from the vegetation of a cultivated field is much greater than that from the naked soil, and this larger evaporation must be supplied from the earth which the roots penetrate. It is plain that a soil separated from bottom water by a gravel bed may suffer greatly from want of moisture during a period of summer weather, when no heavy rains fall, although many light showers wet the surface to a little depth.

I call attention to these details in order to show that the state of the water supply may be really unfavorable to vegetation when no such condition of things is suspected, but must leave to further observation to decide whether the potato scab is in fact attributable to these vicissitudes.

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# FARM EXPERIMENTS AT MAINE STATE COLLEGE,*

CONDUCTED DURING THE YEAR ENDING JUNE 1, 1883, BY G. M. GOWELL, FARM SUPERINTENDENT, AND WALTER BALENTINE, PROFESSOR OF AGRICULTURE.

## EXPERIMENT No. 1.

### *Pig Feeding.*

In undertaking this test there were several points upon which information was sought. First, the comparative results from the different foods employed. Second, At what age of pigs is the most satisfactory growth obtained? Third, the cost of making pork, at present prices of food. Four pure blood Chester white pigs of similar forms and weights, three months of age, were selected for this trial. Up to this age their food had been skimmed milk and wheat bran. They were divided into two sets of two pigs each,—set A being fed through the trial upon fifteen pounds skimmed milk daily, and all the corn meal wet, uncooked, they would consume. A little bone dust was given frequently. Set B received all they would consume of a mixture of seven parts corn meal and one part fish scrap, wet with water, uncooked. At the commencement, set A weighed 170 lbs., and set B 168 lbs.:

SET A.

| Periods of two weeks each. | Weight of Set at end of each period. | FOOD CONSUMED. | Gain in pounds. | Amount of meal required for one pound of gain. |
|---|---|---|---|---|
| 1st period. | 217 lbs. | 210 lbs. milk and 130.5 lbs. meal. | 47 lbs. | 2.77 lbs. |
| 2d | 267 | " " 152 " | 50 | 3.04 |
| 3d | 312 | " " 166.5 " | 45 | 3.7 |
| 4th | 381.75 | " " 226.5 " | 69.75 | 3.25 |
| 5th | 451.5 | " " 266.5 " | 69.25 | 3.85 |
| 6th | 498 | " " 291.5 " | 46.5 | 6.27 |
| 7th | 548 | " " 262 " | 50 | 5.24 |

* Copied from the Report of the Board of Agriculture.



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SET B.

| Periods of two weeks each. | Weight of Set at end of each Period. | FOOD CONSUMED. | Gain in pounds. | Amount of mixture of meal and scrap for 1 pound gain. |
|---|---|---|---|---|
| 1st period. | 210 lbs. | 130 lbs. mixture of meal and scrap. | 42 lbs. | 3.09 lbs. |
| 2d | 246.5 | 168.5 " " " | 36.5 | 4.61 |
| 3d | 313 | 188.5 " " " | 66.5 | 2.83 |
| 4th | 375.5 | 235 " " " | 63 | 3.75 |
| 5th | 439.5 | 262 " " " | 64 | 4.09 |
| 6th | 504 | 278.5 " " " | 64.5 | 4.32 |
| 7th | 556.5 | 253 " " " | 52.5 | 4.82 |

Set A consumed a total of 1495.5 lbs. of meal and 1470 lbs. skimmed milk, and gained 378 lbs., thus requiring to produce one pound of growth, 3.95 lbs. of meal and 3.89 lbs. of milk. Set B consumed 1515.5 lbs. of meal and scrap, and gained 388.5 lbs., requiring 3.9 lbs. of the mixture for one pound of growth. Probably the reason for the low gain made by set A during the sixth and seventh periods, may be found in the fact that they were heavily loaded with fat, and very ripe, requiring much effort to get about their pens. Throughout the trial the tendency of set A was to fatness, while set B grew vigorously but did not become very fat. This result, must, I think, be ascribed to the different foods employed and not to peculiar tendencies existing in the animals, as they were well bred, and at the commencement of the trial very evenly mated, as the pigs in each set continued to be throughout. From the table it will be observed that as they advanced in age and size, it required a greater quantity of food to produce a pound of increase. The showing of set A is not favorable to the feeding value of milk; but the test in this case was not just, for they were fed beyond the point of profit in the sixth and seventh periods. How far the milk in their ration was influential in producing such early maturity and ripeness is a point upon which we shall seek further light. At the expiration of the seventh period the pigs in set A were butchered. Live weight of set was 548 lbs.; dressed weight, 470 lbs.; shrinkage, 78 lbs., or 14¼ per cent.

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| SET A. | DR. |
|---|---|
| To 2 pigs 1 month old | $8.00 |
| To feed until three months old, 200 lbs. bran, $3, and 279 qts. skimmed milk, $2.70 | 5.70 |
| To feed after three months, 1495.5 lbs. corn meal at $1.88 per cwt., delivered | 28.12 |
| To 684 qts. skimmed milk | 6.84 |
| To butchering and marketing | 2.00 |
| | $50.66 |
| SET A. | CR. |
| By 470 lbs. at 11 cents per lb. | $51.70 |

Cost of dressed pork per pound, 10.77 cents.

Set B not being sufficiently fat, its feeding was continued thirty-five days upon corn meal and water. The gain during this time was 176 lbs. upon 724 lbs. meal; 4.11 lbs. of meal being required for one pound of gain. During the feeding upon meal alone, the gain appeared to be in fat rather than in growth. At time of slaughtering they were ripe, but not so excessively fat as were the members of set A. The account is as follows:

| SET B. | DR. |
|---|---|
| To 2 pigs 1 month old | $8.00 |
| To feed until three months old, 200 lbs. bran, $3; 270 qts. skimmed milk, $2.70 | 5.70 |
| To feed after three months, 1515.5 lbs. of mixture at $1.88 per cwt. | 28.49 |
| To feed after seventh period, 720 lbs. corn meal at $1.80 per cwt. | 13.02 |
| To butchering and marketing | 2.00 |
| | $57.21 |
| SET B. | CR. |
| By 608 lbs. pork at 9 cents per pound | $54.72 |

Cost of dressed pork per pound, 9.41 cents.

There was a decline of two cents per pound in the market price of pork between the sales of set A and set B. No account was made of the labor in caring for animals, or for manure resulting from food consumed. It is evident there was no profit in the above feeding. It must not be forgotten that the prime

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object in this test was not to see how cheaply pork could be made, but rather the comparison of feeds and their produce when fed at different ages of animals.

## EXPERIMENT No. 2.

### *Field Experiments with Artificial Manures.*

One set of experiments was designed to study the feeding capacities of some of our more common agricultural plants with special reference to the nitrogen supply. This set of experiments has brought to light some very interesting facts in connection with the ability of the corn crop to obtain its nitrogen from other sources than that supplied in the manure. It has been shown that the majority of our farmers have supplied to this crop a much larger quantity of costly nitrogen than is necessary for its production.

The college has taken part in these experiments from the beginning, and has done its share of the work which in the future is to enable us to grow corn at a much reduced cost.

The soil on the college farm is not adapted to successful corn culture, and the nitrogen experiment with that crop was in consequence abandoned this year. It was our intention to continue the nitrogen experiment on potatoes, but owing to the heavy rains in the first part of the season, the land devoted to experimental purposes was rendered unfit for planting till the season was so far advanced that we were obliged to make our field experiments on beans.

The ground selected for experimental crops was a level field of uniform clay loam, with heavy clay subsoil. It had been in mowing for several years without manure. For the nitrogen experiment, one acre, 435.6 feet in length by 100 feet in width, was taken and divided into twenty equal plots running lengthwise of the field, making the plots five feet wide. The beans were planted in rows 2½ feet apart, giving two rows to each plot. The fertilizers were applied in the drill in the proportion given in the following table.

The questions to be studied under the experiment are,—First, To what extent is it necessary to supply nitrogen in manures to produce a crop of beans? Second, What substances furnish nitrogen in forms best adapted to the crop?

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The plots marked 0 and 00 were planted without manure, to show the natural fertility of the soil. Plots 1–6 were designed to show the effect of the different fertilizers when applied alone and in pairs. In plots 7–9 nitrogen is supplied in nitrate of soda; in 10–12 nitrogen is supplied in sulphate of ammonia; and in 13–15 nitrogen is supplied in dried blood.

| No. of Plot. | | Kind of Fertilizer. | Amount of Fertilizer per plot. | Yield per plot. | Yield per acre. | Increase per acre above unmanured plots. |
|---|---|---|---|---|---|---|
| | | | lbs. | lbs. | lbs. | lbs. |
| | 0 | Nothing | — | 24 | 480 | |
| Preliminary Group. | 1 | Nitrate of Soda | 7.5 | 21½ | 430 | 70 |
| | 2 | Superphosphate | 20.0 | 23 | 460 | 40 |
| | 3 | Muriate of Potash | 6 7 | 25 | 500 | |
| | 4 | Nitrate of Soda | 7.5 | | | |
| | | Superphosphate | 20.0 | 28 | 560 | 60 |
| | 5 | Nitrate of Soda | 7.5 | | | |
| | | Muriate of Potash | 6.7 | 25 | 500 | |
| | 6 | Superphoshate, Mixed | 20.0 | | | |
| | | Muriate of Potash, Minerals | 6.7 | 39½ | 790 | 290 |
| Nitrate of Soda Group. | 7 | Mixed Minerals as No. 6 | 26.7 | | | |
| | | Nitrate of Soda, ⅓ ration | 7.5 | 44 | 880 | 380 |
| | 8 | Mixed Minerals | 26.7 | | | |
| | | Nitrate of Soda, ⅔ ration | 15.0 | 35¼ | 710 | 210 |
| | 9 | Mixed Minerals | 26.7 | | | |
| | | Nitrate of Soda, full ration | 22.5 | 35 | 700 | 200 |
| | 6 a | Mixed Minerals as No. 6 | 26.7 | 35 | 700 | 200 |
| Sulphate of Ammonia Group. | 10 | Mixed Minerals | 26.7 | | | |
| | | Sulph. Ammonia, ⅓ ration | 5.6 | 36 | 720 | 220 |
| | 11 | Mixed Minerals | 26.7 | | | |
| | | Sulph. Ammonia, ⅔ ration | 11.3 | 32½ | 650 | 150 |
| | 12 | Mixed Minerals | 26.7 | | | |
| | | Sulph. Ammonia, full ration | 16.8 | 41 | 820 | 320 |
| | 6 b | Mixed Minerals as No. 6 | 26.7 | 32 | 640 | 140 |
| Dried Blood Group. | 13 | Mixed Minerals | 26.7 | | | |
| | | Dried Blood, ⅓ ration | 11.0 | 59 | 780 | 280 |
| | 14 | Mixed Minerals | 26.7 | | | |
| | | Dried Blood, ⅔ ration | 22.0 | 34 | 680 | 180 |
| | 15 | Mixed Minerals | 26.7 | | | |
| | | Dried Blood, full ration | 33.0 | 40 | 800 | 300 |
| | 6 c | Mixed Minerals as No. 6 | 26.8 | 37 | 740 | 240 |
| | 0 | No manure | — | 26 | 520 | |

An experiment with fertilizers carried on through one year only, decides nothing, especially in a season like the one just

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past, in which, owing to the drought, the crops failed to get the full benefit of the fertilizers applied. It may be well, however, to call attention to the fact that applications of nitrogen with the mixed mineral fertilizers did not produce great gains over the mixed minerals alone.

## EXPERIMENT No. 3.

An acre of land adjoining the nitrogen experiment was devoted to an experiment for growing beans with different forms of phosphoric acid, known as soluble, reverted or precipitated, and insoluble phosphoric acid. Combined with this experiment is one in regard to the quantity of phosphoric acid that can be applied with profitable results. The land used for the experiment was of the same character as that used for the nitrogen experiment, and had received the same treatment in previous years. It was divided into plots of the same dimensions as the plots for the preceding experiment, and in every way treated the same except in the matter of fertilization. Plots from 1–18 received a basal mixture of 10 lbs. sulphate of ammonia and 10 lbs. of muriate of potash. To this mixture was added the fertilizer containing the different forms and quantities of phosphoric acid for the different plots,—dissolved bone black furnishing soluble phosphoric acid, dissolved bone black with chalk furnishing precipitated phosphoric acid, and bone black furnishing insoluble phosphoric acid. The precipitated phosphoric acid was obtained by mixing together equal parts of dissolved bone black and chalk, then wetting down the mixture and allowing it to stand two weeks before using. At the end of that time it showed only a slight trace of soluble phosphoric acid. The table below shows the results of the experiment. Groups I *a*, II *a*, and III *a*, are duplicates of groups I, II, and III.

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| No. of Plot. | Name of Fertilizers. | Yield per plot. | Yield per acre. | Increase above plots with no manure. |
|---|---|---|---|---|
| | | lbs. | lbs. | lbs. |
| 0 | No manure | 25 | 500 | |
| Soluble phosphoric acid. Group I. 1 | Basal mixture, 15 lbs. dissolved bone black | 30 | 600 | 100 |
| 2 | " 10 " " | 28 | 560 | 60 |
| 3 | " 5 " " | 27½ | 550 | 50 |
| Precipitated phos. acid. Group II. 4 | Basal mixt., 15 lbs. dis. bone bl'ck, 15 lbs. chalk | 31 | 620 | 120 |
| 5 | " 10 " 10 " | 28 | 560 | 60 |
| 6 | " 5 " 5 " | 20½ | 590 | 90 |
| Insoluble phos. acid. Group III. 7 | Basal mixture, 15 lbs. bone black | 27½ | 550 | 50 |
| 8 | " 10 " | 29 | 580 | 80 |
| 9 | " 5 " | 28 | 560 | 60 |
| Soluble phosphoric acid. Group I *a*. 10 | Basal mixture, 15 lbs. dissolved bone black | 29 | 580 | 80 |
| 11 | " 10 " " | 30 | 600 | 100 |
| 12 | " 5 " " | 30 | 600 | 100 |
| Precipitated phos. acid. Group II *a*. 13 | Basal mixt., 15 lbs. dis. bone bl'ck, 15 lbs. chalk | 30½ | 610 | 110 |
| 14 | " 10 " 10 " | 26 | 520 | 20 |
| 15 | " 5 " 5 " | 22 | 440 | — 60 |
| Insoluble phos. acid. Group III *a*. 16 | Basal mixture, 15 lbs. bone black | 25 | 500 | |
| 17 | " 10 " | 22 | 440 | — 60 |
| 18 | " 5 " | 23 | 460 | — 40 |
| 00 | No manure | 27½ | 550 | 50 |

The above experiments are submitted without further comment. They will be continued in the future with variations suggested by the experience we have gained in this work.

## EXPERIMENT No. 4.

*Comparison of Feeding Values of early and late cut Hay.*

A field of grass of uniform quantity and quality, consisting mostly of clean herd's-grass, with a very little white-weed intermixed, was selected and divided into plots two and one half rods in width and twenty rods in length. The grass upon the first, third, and fifth plots was cut when in full bloom, July 11; and the second, fourth, and sixth plots were cut twenty days later, August 3, when the seed had become hard, but not sufficiently ripe to shell in harvesting.

The weight of hay cut early, at time of putting in the barn, was 2,931 lbs. per acre; weight of same Feb. 14, 2,675 lbs.; shrinkage, 8¾ per cent.

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The weight of hay cut late, at time of harvesting, was 3,150 lbs. per acre; weight of same Feb. 14, 2,662 lbs.; shrinkage, 15½ per cent.

The greater shrinkage in the late cut hay is probably owing to its being weighed directly from the bunches that had stood in the field over night. The amount of winter dry hay from each cutting was practically the same.

Chemical analysis of the hay showed the following composition:

EARLY HAY.

| | |
|---|---|
| Moisture | 10.7 per cent. |
| Protein | 6. |
| Fat | 3.3 |
| Nitrogen-free extract | 48.5 |
| Crude fibre | 27.7 |
| Ash | 3.8 |

LATE HAY.

| | |
|---|---|
| Moisture | 7.8 per cent. |
| Protein | 4.6 |
| Fat | 2.8 |
| Nitrogen-free extract | 51. |
| Crude fibre | 30.2 |
| Ash | 3.6 |

To test the comparative feeding value of this hay, two cows, as evenly mated as possible, were selected, each being cross-bred,—seven eighths Jersey and one eighth Ayrshire. They were comparatively fresh, having been in milk but a few weeks. They each received three lbs. of corn meal, three lbs. of cotton-seed meal, one and one half lbs. of bran, and twenty lbs. of hay daily throughout the entire period of feeding.

Bess was fed during the first period of twelve days upon late hay, the first six being in preparation and to overcome the influence of previous feeding; and the milk product of the last six days of the period was taken as the result of the late hay. At the close of the first period her feed was changed to early hay, and she was fed upon this during the second period of twelve days, the first six to destroy the influence of previous feeding as before, and the last six the milk produced represented

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the result of the early hay consumed during that time. The third period her hay was the late cut, fed as in the first. This feeding alternately on late and early hay was continued through six periods of twelve days each, or seventy-two days.

The cream was raised and butter made from it under similar conditions during each period, the butter being made from the milk of one day, and calculated for the period from the number of pounds of milk required for one pound of butter. The total amount of fat contained in each day's milk was ascertained by chemical examination.

This same course of feeding and testing was repeated with Pet, excepting that when Bess had late hay Pet had early, and when Bess had early Pet had late. This was for the purpose of equalizing the influence of the variation of temperature that might occur.

BESS.

| Periods of six days each. | Feed. | Pounds milk for period. | Per cent. of cream. | Pounds milk required for one pound butter. | Pounds butter for period. | Pounds fat in milk for period. | Weight of cows at end of periods. |
|---|---|---|---|---|---|---|---|
| First..... | Late Hay..... | 160.12 | 21 | 14.46 | 11.07 | 5.88 | 860 |
| Second..... | Early Hay..... | 163.87 | 19 | 18.54 | 8.33 | 6.33 | 860 |
| Third..... | Late Hay..... | 149.18 | 19 | 19.40 | 7.69 | 5.97 | 865 |
| Fourth..... | Early Hay..... | 150.25 | 22 | 14.09 | 10.23 | 5.99 | 860 |
| Fifth..... | Late Hay..... | 133.68 | 20 | 15.41 | 8.67 | 5.51 | 870 |
| Sixth..... | Early Hay..... | 144.18 | 19 | 21.44 | 6.72 | 5.63 | 845 |
| | | PET. | | | | | |
| First..... | Early Hay..... | 187.37 | 21.5 | 19.46 | 9.62 | 6.33 | 862 |
| Second..... | Late Hay..... | 169.37 | 19.5 | 20.5 | 8.21 | 6.51 | 865 |
| Third..... | Early Hay..... | 178.43 | 20. | 21.75 | 8.20 | 6.73 | 862 |
| Fourth..... | Late Hay..... | 157.63 | 22.5 | 17.04 | 9.25 | 5.88 | 910 |
| Fifth..... | Early Hay..... | 166.06 | 20. | 17.69 | 9.38 | .35 | 912 |
| Sixth..... | Late Hay..... | 151.12 | 20. | 18.94 | 7.97 | 5.55 | 905 |

It was found that 270 lbs. of mixed grain and 720 lbs. of early hay produced 990.12 lbs. of milk, which yielded 52.98 lbs.

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of butter, and the milk contained 37.36 lbs. of fat. The same quantity and quality of grain as above, fed in connection with 720 lbs. of late hay, gave 921.15 lbs. of milk, which yielded 52.85 lbs. of butter, the milk containing 35.3 lbs. of fat.

In this test the comparative value of the early and late hay for milk production was as 100 to 93.34; or, the daily feeding ration of 20 lbs. of early hay was equal to 21.42 lbs. of late hay for the same purpose. There was practically no difference in the amounts of butter obtained from each fodder. It was feared that the appetites of the animals might not be as good for the late as for the early hay, but such was not the case to any serious extent. In only two of the six changes from early to late was there any dislike exhibited, and this was overcome during the first day of feeding upon it.

In one of the six changes from late to early there was nearly the same dislike manifested. This was somewhat surprising, as the early hay was green and fresh, while the late was evidently nearly ripe.

It must, however, be borne in mind that the weather during the last haying season was unusually favorable to late standing grass, no rain of consequence occurring after July 10.

These results show much less difference in the nutritive value and palatability of hay harvested when in full bloom and that harvested at a much later period, than has generally been supposed to exist.

## EXPERIMENT No. 5.

### *Hungarian and Mixed Hay compared in Feeding.*

The important position which Hungarian grass is destined to occupy among the forage crops of the state, together with the lack of accurate data bearing upon its feeding value, prompted its comparison by careful feeding tests with a good quality of mixed Timothy and red clover hay. When it is remembered that Hungarian is an annual, to be sown in June, ready for harvest in August, and yielding from two to four tons of cured hay per acre, succeeding upon light or heavy soils if sufficiently fertile, its value as a means of increasing the stock-carrying capacity of farms becomes apparent.

The Hungarian hay fed was grown last season and harvested

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in fine order, as was also the mixed hay with which it was compared.

Two cows fresh in milk—"Helen Hart" and "Maggie 3d"—were selected and fed upon the same plan that the animals were in the late and early hay test, the cream, butter, and fats being obtained by the same process there employed.

They each received the same quantity and quality of mixed grain throughout, viz., 3 lbs. corn meal, 3 lbs. cotton-seed meal, and one and one half lbs. of bran daily. Each one also consumed twenty-two pounds of Hungarian or mixed hay per day. This course extended through five periods, or sixty days.

The composition of the Hungarian and mixed hay was as follows:

HUNGARIAN HAY.

| | |
|---|---|
| Moisture | 8.7 per cent. |
| Protein | 6.8 |
| Fat | 3.5 |
| Nitrogen-free extract | 48.7 |
| Crude fibre | 26.4 |
| Ash | 5.9 |

MIXED HAY.

| | |
|---|---|
| Moisture | 8.2 per cent. |
| Protein | 5.5 |
| Fat | 2.7 |
| Nitrogen-free extract | 48. |
| Crude fibre | 30.8 |
| Ash | 3.9 |

HELEN HART.

| Periods of six days each. | Feed. | Pounds milk. | Per cent. of cream. | Pounds milk required for one pound butter. | Pounds butter. | Pounds fat in milk. | Weight of cows at end of periods. |
|---|---|---|---|---|---|---|---|
| First..... | Hungarian..... | 174.62 | 22.5 | 19.04 | 9.176 | 6.09 | 985 |
| Second. ..... | Timothy and Clover | 163.93 | 25.5 | 15.43 | 10.624 | 6.21 | 990 |
| Third..... ..... | Hungarian..... | 173. | 19. | 22.25 | 7.775 | 6.13 | 990 |
| Fourth..... | Timothy and Clover | 155.18 | 21.5 | 22.5 | 6.897 | 5.76 | 1005 |
| Fifth..... | Hungarian..... | 159. | 21. | 22.44 | 7.085 | 6.04 | 980 |

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MAGGIE 3D.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| First..... | Timothy and Clover | 204.5 | 22. | 23.12 | 8.845 | 6.39 | 1060 |
| Second..... | Hungarian..... | 213.06 | 22. | 23.16 | 9.199 | 7.18 | 975 |
| Third..... | Timothy and Clover | 187.18 | 22. | 24.59 | 7.612 | 6.37 | 1023 |
| Fourth..... | Hungarian..... | 206. | 21.5 | 19.67 | 10.506 | 7.27 | 1026 |
| Fifth..... | Timothy and Clover | 193.43 | 21.5 | 23.32 | 8.295 | 6.76 | 1040 |

Two hundred and twenty-five pounds of mixed grain and 660 lbs. of Hungarian hay furnished 925.68 lbs. of milk, and 43.743 lbs. of butter—the milk containing 32.71 lbs. of fat.

The same quantity of grain and 660 lbs. mixed hay gave 904.22 lbs. of milk, 42.273 lbs. of butter, and the milk contained 31.49 lbs. of fat.

The relative value of the Hungarian to the mixed hay was as 100 to 97.68 for milk production, and for butter production as 100 to 96.64.

The twenty-two pounds mixed hay was all the animals would consume per day. The same quantity of Hungarian was eaten with much apparent relish, and evidently more would have been utilized had it been supplied.

## EXPERIMENT No. 6.

*Practical Comparison of the feeding values of Corn Meal, Cotton-seed Meal, and Wheat Bran.*

To learn the comparative practical feeding values of cotton-seed meal, corn meal, and bran as milk and butter producers, when used in connection with good hay, was the purpose of this feeding test.

Two cows, Clover and Rockaway, were fed through seven twelve-day periods upon good mixed hay, the quality of which was uniform throughout the whole time of feeding. Rockaway received twenty pounds daily, while nineteen pounds was all Clover would consume.

During the first period Clover received, in addition to the hay, six lbs. per day of cotton-seed meal; during the second period, six lbs. of corn meal; and during the third period, six lbs. of wheat bran or shorts. In the fourth, fifth, and sixth periods

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the work of the first three periods was duplicated; in the seventh period the feed was hay alone.

Rockaway was fed through the several periods upon the same plan pursued with Clover. The resulting butter and fats were obtained by the same processes employed in the early and late hay test.

The cows at the commencement of this experiment had been in milk some seven months, which accounts for their small yields.

The grain used in this experiment, as well as in experiments Nos. 4 and 5, had the following compositions, and may be considered as fair representatives of these feeds, as usually found in the markets:

COTTON-SEED MEAL.

| | |
|---|---|
| Moisture | 9. per cent. |
| Protein | 40.2 |
| Fat | 12.5 |
| Nitrogen-free extract | 24.7 |
| Crude fibre | 5.2 |
| Ash | 8.8 |

CORN MEAL.

| | |
|---|---|
| Moisture | 14.6 per cent. |
| Protein | 9.2 |
| Fat | 3.6 |
| Nitrogen-free extract | 69.1 |
| Crude fibre | 1.9 |
| Ash | 1.6 |

WHEAT BRAN.

| | |
|---|---|
| Moisture | 11.6 per cent. |
| Protein | 14. |
| Fat | 2.9 |
| Nitrogen-free extract | 56.8 |
| Crude fibre | 8.4 |
| Ash | 6.3 |

The hay fed in this test was the same as that used in experiment No. 5, against Hungarian.

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CLOVER.

| Periods of six days each. | Feed. | Pounds milk for period. | Per cent. of cream. | Pounds milk required for one pound butter. | Pounds butter for period. | Pounds fat in milk for period. | Weight of cows at end of periods. |
|---|---|---|---|---|---|---|---|
| First..... | Cotton-seed meal.... | 94.25 | 22.5 | 25.20 | 3.74 | 3.27 | 847 |
| Second..... | Corn meal..... | 87.81 | 19.5 | 28.25 | 3.104 | 3.22 | 825 |
| Third..... | Bran..... | 73.62 | 21. | 18.9 | 3.89 | 2.92 | 835 |
| Fourth..... | Corn meal..... | 87.06 | 24. | 20.4 | 4.267 | 3.36 | 855 |
| Fifth..... | Cotton-seed meal.... | 90.06 | 19.5 | 20.6 | 4.372 | 2.91 | 865 |
| Sixth..... | Bran..... | 76.56 | 21.5 | 19.24 | 3.979 | 2.98 | 862 |
| Seventh..... | Nothing..... | 45.75 | 24.5 | 17.12 | 2.671 | | 864 |

ROCKAWAY.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| First..... | Corn meal..... | 105.62 | No separation of cream from milk detectable. | 21.98 | 4.85 | 4.20 | 1010 |
| Second..... | Cotton-seed meal.... | 103.37 | | 19.50 | 5.301 | 4.82 | 1007 |
| Third..... | Bran..... | 94.12 | | 18.66 | 5.04 | 3.97 | 1020 |
| Fourth..... | Cotton-seed meal.... | 107.5 | | 23.40 | 3.785 | 4.52 | 1012 |
| Fifth..... | Corn meal..... | 108.68 | | 23.83 | 4.561 | 4.75 | 1045 |
| Sixth..... | Bran..... | 98.5 | | 25.53 | 3.858 | 4.20 | 1013 |
| Seventh..... | Nothing..... | 62. | | 25. | 2.481 | | 1021 |

It was found that 468 lbs. of hay and 144 lbs. of cotton-seed meal gave 395.18 lbs. of milk, 17.198 lbs. of butter, and 15.52 lbs. of fat.

That 468 lbs. of hay and 144 lbs. of corn meal gave 389.17 lbs. of milk, 16.782 lbs. of butter, and 15.53 lbs. of fat.

That 468 lbs. of hay and 144 lbs. of bran gave 342.8 lbs. of milk, 16.767 lbs. of butter, and 14.07 lbs. of fat.

The relative values of these foods for milk production are represented as follows: Cotton-seed meal, 100; corn meal, 98.4; bran, 86.7. As butter producers, cotton-seed meal, 100; corn meal, 97.5; bran, 97.4.

Regarding the economy of the foods, the cotton-seed and corn meal each cost one and one half cents per lb., and the bran cost one and one fourth cents per lb.

The cotton-seed used in the production of 100 lbs. of milk

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cost 54.6 cents; the corn meal used in the production of 100 lbs. of milk cost 55.5 cents; the bran used in the production of 100 lbs. of milk cost 52.5 cents. The cotton-seed meal used in the production of 1 lb. of butter cost 12.56 cents; the corn meal used in the production of 1 lb. of butter cost 12.87 cents; the bran used in the production of 1 lb. of butter cost 10.73 cents. These costs are in addition to the value of hay employed.

Had these materials been used in connection with a poor quality of hay or straw, the results might have varied more widely in their relations to each other. Again: Had the cows fed been fresh in milk rather than in the latter part of their year's work, the yield from the foods would have been much larger, costing less per pound, yet relatively they might not have been affected.

The several samples of butter made from cotton-seed meal were very good in both texture and color. Those from bran were so much like the cotton-seed samples that no difference could be determined; while those produced from corn meal were superior in firmness and color to all others. The butter from hay, with no grain, was of decidedly inferior quality in every respect.

It is not claimed that these experiments definitely settle any disputed point or mooted question. Many such are required before a truth can be established; yet, from the length of time over which they have extended, the number of periods employed, and the care devoted to the work throughout, they do furnish data which may not be disregarded.

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# AMERICAN AGRICULTURE.

BY F. A. WALKER.

[The following article, by Mr. F. A. Walker, late superintendent of census, originally printed in the *Princeton Review*, is here reproduced as containing some points of interest regarding American as contrasted with European agriculture. The addition made to this article, or "the future," was first published in the *Agricultural Review*.]

It is proposed in this paper to take a general view of the characteristics of American agriculture. Ever since the revolt of the British colonies nullified the royal prohibition of the settlement of the Ohio valley, the frontier line of our population has been moving steadily westward, passing over one, two, and even three degrees of longitude in a decade, until now it rests at the base of the Rocky Mountains. The report of the public land commission to congress, just issued from the press, states that the amount of arable lands still remaining subject to occupation under the homestead and preëmption acts is barely sufficient to meet the demand of settlers for a year or two to come. This would seem a fitting point from which to review the course of American agriculture through the last hundred years; to inquire what have been its methods, and what it has accomplished.

The subject may be treated under the following titles:

1. As to the tenure of the soil.
2. As to character of the cultivators as a class.
3. As to the freedom and fulness of experiment upon the relations of crops to climate and to local soils.



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4. As to what has been done biologically to promote our agriculture.

5. As to what has been done mechanically.

6. As to what has been done chemically:—under which title we shall have occasion to explain the westward movement of the field of cultivation of wheat and corn, and the south-westward movement of the cotton culture.

*First.* The tenure of land in the United States is highly popular. Throughout the Northern and Western states this has always been so. The result has not been wholly due, as one is apt to think, to the existence of vast tracts of unoccupied land "at the West," whatever that phrase may at the time have meant, whether western New York in 1810, or Ohio in 1830, or Iowa in 1850, or Dakota in 1880. An aristocratic holding of land in New England would have been consistent with a great breadth of free lands across the Missouri, quite as fully as such a holding of land in England is consistent with the existence of boundless fertile tracts in Canada and Australia under the laws of the same empire.

The result in the United States has been due partly to the fact just noted, combined with the liberal policy of the government relative to the public domain; partly to excellent laws for the registration of titles and the transfer of real property in nearly every state of the Union; and partly to the genius of our people, their readiness to buy or sell, to go East or to go West, as a profit may appear.

But while we have thus enjoyed a highly popular tenure of the soil, this has not been obtained by the force of laws compelling the subdivision of estates, as in France, under the law of "partible succession;"* nor has it been carried so far as to create a dull uniformity of petty holdings. If, as Professor Roscher remarks, "a mingling of large, medium, and small properties, in which those of medium size predominate, is the most wholesome of political and economical organizations," the

*A strong reaction is manifest in France against the requirement of the code that all estates must, at the death of the proprietor, be equally divided among all the children. It is objected to as causing the subdivision of the land into patches too small for profitable cultivation, and as breaking up commercial and manufacturing establishments, rendering it a rare thing that a son should succeed his father in his business.

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United States may claim to have the most favorable tenure of the soil among all the nations of earth. We have millions of farms just large enough to profitably employ the labor of the proprietor and his growing sons; while we have, also, multitudes of considerable estates upon which labor and moneyed capital, live-stock and improved machinery, are employed under skilled direction; and we have, lastly, those vast farms, the wonder of the world, in Illinois and California, where 1,000 or 5,000 acres are sown as one field of wheat or corn, or, as on the Dalrymple farms in Dakota, where a brigade of six-horse reapers go, twenty abreast, to cut the grain that waves before the eye almost to the horizon.

Whereas in France the number of estates is almost equal to the number of families engaged in agricultural pursuits, the number of separate farms with us is somewhat less than one half the number of persons actually engaged in agriculture, there being, on the average, perhaps 210 to 220 workers to each 100 farms.

At the South the institution of slavery, with the organization of labor and the social ideas carried along by slavery, generated and maintained a comparatively aristocratic tenure of the soil. The abolition of slavery, accomplished as it was by the violence of war, has not only created a new class desirous of acquiring land, but, by impoverishing the former masters, has brought no small proportion of the old plantations into the market, with the result that farms have been rapidly multiplied in this section. Since 1870 the number of farms in thirteen of the late slave states, for which I have the statistics, has increased 65 per cent.; and this movement towards the subdivision of the large plantations is likely, in the absence of capital to carry on extensive operations, to continue until the tenure of the soil shall be relatively even more popular than at the North. Mr. Edward Atkinson, an authority on the subject, holds that this minute subdivision of land will be peculiarly favorable to the cultivation of cotton.

Of the farms into which the cultivated area of the United States is divided, 60 or even 70 per cent. are cultivated by their owners. In the Northern states the proportion rises to 80 per cent., or even higher. Connecticut, Maine, and Massachusetts,

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of the New England states, and Wisconsin, Michigan, and Minnesota, of the North-Western states, show an excess over 90 per cent. The rent of leased farms in New England is in a large majority of cases paid in money. In all other sections of the country rents are generally stipulated to be paid in some definite share of the produce, the proportion in many of the Southern and Western states being three, four, or five farms rented for shares of the produce to one for which a money rent is paid.

*Second.* Of the character of the cultivators of the soil in the United States it will not be necessary to speak at length. Confining our view to the country north of the Potomac and the Ohio, we say that, unlike the cultivators in any country of Europe except Switzerland and perhaps Scotland, they have at no stage of our history constituted a peasantry in any proper sense of the term. The actual cultivators of the soil here have been the same kind of men precisely as those who filled the professions, or were engaged in commercial and mechanical pursuits. Of two sons of the same mother, one became a lawyer, perhaps a judge, or went down to the city and became a merchant, or gave himself to political affairs and became a governor or a member of congress; the other stayed upon the ancestral homestead, or made a new one for himself and his children out of the public domain farther west, remaining through his life a plain, hardworking farmer.

Now this condition of things has made American to differ from European agriculture by a very wide interval. There is no other considerable country in the world where equal mental activity and alertness have been applied to the cultivation of the soil, as to trade and so-called industry.

We have the less occasion to dwell now upon this theme because we shall be called to note, under several heads following, striking illustrations of the effects of this cause in promoting the success of American agriculture.

*Third.* To ascertain what are the adaptations of any piece of ground to the cultivation of any single crop, and what variety and order of crops will best bring out the capabilities of soil and climate in the production of wealth, may seem a simple thing; but it is not. It is so far from being a simple thing, that a race of men, not barbarous, but, as we call them, civilized, may in-

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habit a region for an indefinite period and this thing not be done at all. Such may be the lack of enterprise, such the force of tradition, that crops may be cultivated from generation to generation, and from century to century, while yet the question has never been fairly determined whether the agriculture of the district might not advantageously be reinforced and the soil be relieved by the introduction of new crops, or even by throwing out the traditionary crops altogether.

Gonzales, in his "Tour of England" (1730), wrote,—"And my tutor told me that a good author of their own made this remark of Wiltshire, 'that an ox left to himself would, of all England, choose to live in the north of this county, a sheep in the south part of it, and a man in the middle of both, as partaking of the pleasure of the plain and the plenty of the deep country.'" The remark does not exaggerate the nicety of those distinctions which determine the range of the profitable cultivation, whether of an animal or a vegetable species. A certain rough canvass of the agricultural capabilities of any district is easily made, and a process of elimination early takes place by which certain crops are discarded, for once and for all, as hopeless. But among the great variety of crops which may be cultivated in any region, justly to discriminate between the good and the very good, and to reject those which, though within the "limit of tolerance," as the money-writers say, are yet on the whole, and in the long run, not profitable, demands long, careful, and elaborate experimentation. Beyond this is the selection of varieties within the retained species, in which alone may reside the possibilities of success or failure,—the fortunate choice of varieties, among the almost indefinite number, often making all the difference between profit and no profit.

To do this work satisfactorily requires great mental enterprise and what we may call intellectual curiosity, a natural delight in experimentation, a ready apprehension combined with persistency, in due measure, and with a sound judgment. To do this work both well and quickly, being neither slow in testing new and promising subjects, nor easily discouraged by the accidents which beset initiation and experiment, nor yet reluctant in drawing the proper inference from failure, would task the intellectual powers of any race of men.

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In Europe the knowledge of soils and of climate, on which the cultivation of large estates or peasant properties is based, is the accumulation of hundreds of years of experience. In the United States the course of settlement has called upon our people to occupy virgin territory as extensive as Switzerland, as England, as Italy, and latterly as France or Germany, every ten years. And it has been in meeting the necessity of a rapid, rough-and-ready reconnaissance of new soils under varying climatic conditions, that the character of our cultivating class, as indicated under the previous title, has come most strikingly into play.

During the colonial period the work of experiment had so far advanced that every crop but one (sorghum) now recognized in the official agricultural statistics of the country was cultivated within the region east of the Alleghanies. In the long course of experiment which has resulted in the naturalization of the crops now so well known in New England, the following had, according to Professor Brewer, been tried and rejected from our agriculture, viz., hemp, indigo, cotton, madder, millet, spelt, lentils, and lucern.

But while so much of the adaptations of our general climate to agriculture had been thus early mastered, much in the way of studying the agricultural capabilities of the infinite varieties of soil subject to this climate remained to be done within the region then occupied; while with every successive extension of the frontier of settlement the same work has had to be done for the new fields brought under cultivation. To say with what quick-wittedness and openness of vision, what intellectual audacity yet strong common-sense, what variety of resource and facility of expedients, what persistency yet pliancy, the American farmer has met this demand of the situation, would sound like extravagant panegyric. No other agricultural population of the globe could have encountered such emergencies without suffering tenfold the degree of failure, loss, and distress which has attended the westward movement of our population during the past one hundred years.

*Fourth.* In asking what has been done biologically to promote American agriculture, we have reference to the application of the laws of vegetable and animal reproduction, as dis-

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covered by study and experiment, to the development of new varieties of plants and of animals, or to the perfection of individuals of existing varieties. In this department of effort the success of the American farmer has been truly wonderful, and our agriculture has profited by it in a degree which it would be difficult to overestimate. A few examples will suffice for our present occasion.

Receiving the running horse from England, we have so improved the strain that for the two years past, notwithstanding the unlimited expenditure upon racing studs in England, notwithstanding that English national pride is so much bound up in racing successes, and notwithstanding the grave disadvantages which attend the exportation of costly animals and their trial under the conditions of a strange climate, the honors of the British turf have been gathered, in a degree almost unknown in the history of British racing, by three American horses; and while Iroquois was last summer winning his unprecedented series of victories, two if not three American three-year-olds, generally believed to be better than Iroquois, were contesting the primacy at home.

The trotting horse we have created, certainly the most useful variety of the equine species, and we have improved that variety in a degree unprecedented, I believe, in natural history. Two generations ago the trotting of a mile in 2 minutes and 40 seconds was so rare as to give rise to a proverbial phrase indicating something extraordinary: it is now a common occurrence. "But a few years ago," wrote Professor Brewer in 1876, "the speed of a mile in 2:30 was unheard of; now perhaps five or six hundred horses are known to have trotted a mile in that time." The number is to-day perhaps nearer one thousand than five hundred. Steadily onward have American horse-racers pressed the limit of mile-speed, till, within the last three seasons, the amazing figures 2:10 have been reached by one trotter and closely approached by another.

Take an even more surprising instance. About 1800 we began to import in considerable numbers the favorite English cattle, the Short-horn. The first American Short-horn herd-book was published in 1846. In 1873 a sale of Short-horn cattle took place in western New York, at which a herd of 109 head

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was sold for a total sum of $382,000, one animal, a cow, bringing $40,600; another, a calf five months old, $27,000, both for the English market. To-day Devons and Short-horns are freely exported from New York and Boston to England to improve the native stock.

In 1793 the first merino sheep, three in number, were introduced into this country, though, unfortunately, the gentleman to whom they were consigned, not appreciating their peculiar excellences, had them converted into mutton. Since that time American wool has become celebrated both for fineness of fibre and for weight of fleece. The finest fibre by microscopic test, ever anywhere obtained, was clipped about 1850 from sheep bred in western Pennsylvania. More recently the attention of our wool-growers has been especially directed to increasing the quantity rather than to improving the quality of the wool.

Illustrations of the success of American agriculture, biologically, might be drawn from the vegetable kingdom, did space permit.

*Fifth.* To ask what has been done mechanically to promote our agriculture is to challenge a recital of the better half of the history of American invention. Remarkable as have been the mechanical achievements of our people in the department of manufacturing industry, they have been exceeded in the production of agricultural implements and machinery, inasmuch as, in this branch of invention, a problem has been solved that does not present itself for solution, or only in a much easier shape, in those branches which relate to manufactures,—the problem, namely, of combining strength and capability of endurance with great lightness of parts.

In no other important class of commercial products, except the American street carriage or field wagon, are these desired qualities so wonderfully joined as in the American agricultural machines, while the special difficulty arising from the necessity of repairs on the farm, far from shops where the services of skilled mechanics could be obtained, has been met by the extension to this branch of manufacture of the principle of interchangeable parts, a principle purely American in its origin. Through the adoption of this principle by the makers of agricultural machines, a farmer in the Willamette valley of Oregon is

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enabled to write to the manufacturer of his mower or reaper or thresher, naming the part that has been lost or become broken or otherwise useless, and to receive by return mail, third-class, for which the government rate will be only two or three shillings, the lacking part, which with a wrench and a screw-driver he can fit into its proper place in fifteen minutes.

All the agricultural machines of to-day are not originally of American invention, although most of them are, in every patentable feature; but I am not aware that there is at present in extensive use one which does not owe it to American ingenuity that it can be popularly used. Without the improvements it has received here, the best of foreign inventions in this department of machinery would have remained toys for exhibition at agricultural fairs, or machines only to be employed on large estates under favorable conditions.

But more, even, than the ingenuity of inventors and manufacturers has been required to give to agricultural machinery the wide introduction and the marvellously successful applications it has had in the cultivation of our staple crops East and West. "Experienced mechanicians," says Professor Hearn, "assert that, notwithstanding the progress of machinery in agriculture, there is probably as much sound practical labor-saving invention and machinery unused as there is used, and that it is unused solely in consequence of the ignorance and incompetency of the work-people." This remark, which is perfectly true of England, and the force of which would have to be multiplied four-fold in application to the peasantry of France or Austria, utterly fails of significance if applied to the United States. It is because mechanical insight and aptitude, in the degree respecting which the term "mechanical genius" may properly be used, are found throughout the mass of the American people, that these products of invention and skill have been made of service on petty farms all over our land, and in the most remote districts. Lack of mechanical insight and aptitude, in the full degree requisite for the economical use and care of delicate and complicated machinery, is almost unknown among our native Northern people. Not one in ten but has the mechanical sense and skill necessary for the purpose.

But it has not been through the invention and wide applica-

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tion of agricultural machinery alone that the peculiar and extraordinary mechanical genius of our people has increased our national capacity for agricultural production. In what we may call the daily commonplace use of this faculty, throughout what may be termed the pioneer period, and, in a diminishing degree, through each successive stage of settlement and industrial development, the American farmer has derived from this source an advantage beyond estimation in dealing with the perpetually varying exigencies of the occupation and cultivation of the soil.

*Sixth.* When we ask what has been done chemically to promote American agriculture, we reach at once the most characteristic differences between our cultivation of the soil and that prevailing in older countries; and we have, at the same time, the explanation of the contemptuous manner in which our agriculture is almost universally spoken of by European writers. Did I say contemptuous? The word "indignant" would often better express the feeling aroused in these writers by the contemplation of our dealing with the soil, which, from their point of view, they cannot but regard as wasteful, wanton earth-butchery. "In perusing the volumes of Messrs. Parkinson, Faux, Fearon, and others," says Hinton, in his "History of the United States," "some hundred pages of invective occur because the Americans will persist in taking up fresh land instead of the more costly process of manuring a worn-out soil; will raise extensive crops instead of highly cultivating and beautifying a small space."

A few British tourists, indeed, notably Professor Johnston and Mr. James Caird, have shown a somewhat juster appreciation of American agriculture; but even these have given only a qualified approval of our method of dealing with the soil, and have fallen ludicrously short of the truth in attempting to fix the limit of time during which this policy could be maintained.

Johnston, one of the best writers of his time on agricultural chemistry, publishing his "Notes on North America" in 1851, expressed his belief that the exportable wheat of the continent, as a whole, was "already a diminishing quantity." In the light of to-day the following reads somewhat strangely:

"It is fair and reasonable, therefore, I think, to conclude,

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until we have better data, that the wheat-exporting capabilities of the United States are not so great as they have by many in Great Britain hitherto been supposed; that they have been overstated on the spot, and that our wheat-growers at home have been unduly alarmed by these distant thunders, the supposed prelude of an imaginary torrent of American wheat, which was to overwhelm everything in Great Britain, involving farmers and landlords in one common ruin."

What, then, has been this American way of dealing with the soil to which our English brethren have so strongly made objection?

The American people, finding themselves on a continent containing an almost limitless breadth of arable land, of fair average fertility, having little accumulated capital and many urgent occasions for every unit of labor power they could exert, have elected—and in doing so they are, I make bold to say, fully justified, on sound economical principles—to regard the land as practically of no value and labor as of high value; have, in pursuance of this theory of the case, systematically cropped their fields, on the principle of obtaining the largest crops with the least expenditure of labor, limiting their improvements to what was required for the immediate purpose specified, and caring little about returning to the soil any equivalent for the properties taken from it by the crops of each successive year. What has been returned has been only the manure generated incidentally to the support of the live-stock needed to work the farm. In that which is for the time the great wheat and corn region of the United States, the fields are, as a rule, cropped continuously, without fertilization, year after year, decade after decade, until their fertility sensibly declines.

Decline under this regimen it must, sooner or later, later or sooner, according to the crop and according to the degree of original strength in the soil. Resort must then be had to new fields of virgin freshness, which with us in the United States has always meant "The West." When Professor Johnston wrote, the granary of the continent had already moved from the flats of the upper Saint Lawrence to the Mississippi valley, the north and south line which divided the wheat product of the United States into two equal parts being approximately the line

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of the eighty-second meridian. In 1860 it was the eighty-fifth; in 1870, the eighty-eighth; in 1880, the eighty-ninth.

Meanwhile, what becomes of the regions over which this shadow of partial exhaustion passes, like an eclipse, in its westward movement? The answer is to be read in the condition of New England to-day. A part of the agricultural population is maintained in raising upon limited soils the smaller crops, garden vegetables, and orchard fruits, and producing butter, milk, poultry, and eggs for the supply of the cities and manufacturing towns which had their origin in the flourishing days of agriculture, which have grown with the age of the communities in which they were planted, and which, having been well founded when the decadence of agriculture begins, flourish the more on this account, inasmuch as a second part of the agricultural population, not choosing to follow the westward movement of the grain culture, is ready with its rising sons and daughters to enter the mill and the factory.

Still another part of the agricultural population gradually becomes occupied in the higher and more careful culture of the cereal crops on the better portion of the former breadth of arable land, the less eligible fields being allowed to spring up in brush and wood; deeper plowing and better drainage are resorted to; fertilizers are now employed to bring up and keep up the pristine fertility of the soil.

And thus begins the serious systematic agriculture of an old state. Something is done in wheat, but not much. New York raised 13,000,000 bushels in 1850; thirty years later, when her population has increased 70 per cent., she raises 13,000,000 bushels. Pennsylvania raised 15,500,000 bushels in 1850, with a population of 2,250,000; in 1880, with 4,500,000 inhabitants, she raises 19,500,000 bushels. New Jersey raised 1,600,000 bushels then; she raises 1,900,000 now.

More is done in corn, that magnificent and most prolific cereal; more still in buckwheat, barley, oats, and rye. Pennsylvania, though the tenth state in wheat production, stands first of all the Union in rye, second in buckwheat, and third in oats; New York, the same New York whose Mohawk and Genesee valleys were a proverb through the world forty years ago, is but the thirteenth state in wheat, but is first in buckwheat, second in barley, and third in rye.

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It is in the way described that Americans have dealt with the soil opened to them by treaty or by purchase. And I have no hesitation in saying that posterity will decide, first, that it was both economically justifiable and politically fortunate that this should be done; and, secondly, that what has been done was accomplished with singular enterprise, prudence, patience, intelligence, and skill.

It will appear, from what has been said under the preceding titles, that I entertain a somewhat exalted opinion concerning American agriculture. Indeed I do. To me the achievements of those who in this new land have dealt with the soil, under the conditions so hurriedly and imperfectly recited, surpass the achievements of mankind in any other field of economic effort. With the labor power and capital power which we have had to expend during the past one hundred years, to have taken from the ground these hundreds, these thousands of millions of tons of food, fibre, and fuel for man's uses, leaving the soil no more exhausted than we find it to-day; and, meantime, to have built up, out of the current profits of this primitive agriculture, such a stupendous fund of permanent improvements in provision for future needs and in preparation for a more advanced industry and a higher tillage,—this certainly seems to me not only beyond the achievement, but beyond the power, of any other race of men.

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So much in retrospect. Let us now turn to the future.

As we cast our eyes over the broad surface of the United States, it might seem that our people had, as yet, little more than commenced the occupation of their patrimonial estate. The wholly unsettled area of the United States, as shown by the census of 1880, amounted to about 1,400,000 square miles, being nearly one half of the area of the country.

Where are the vacant tracts? What is their character in the respects of soil and climate? What their prospective capability of agricultural production? Will they remain unoccupied through the period while our population is rising from fifty to one hundred millions, as they have remained without inhabitants

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while our population has increased from four to fifty millions? or will the thirty or forty years necessary to raise our numbers to that gigantic total just mentioned find these regions covered with shops and farms, schools and churches, supporting their share of the century of millions of our people, and contributing their stores of grain and meat to feed the populations of Europe?

The unsettled area of the thirteen original states aggregates 14,500 square miles. It is composed of the northern two fifths of Maine, a small tract in New Hampshire, and the Adirondack regions of New York.

Inasmuch as the unsettled area of the country east of the Appalachians has been reduced by but 10,000 square miles during the fifty years since 1830, when this region embraced 70 per cent. of the population of the United States, to the present time, when it embraces but 40 per cent. of a population which has increased fourfold, it is not unreasonable to suppose that, in the future as in the past, intending settlers will pass these regions by to seek more fertile soils and a warmer sun beyond the great Atlantic chain.

Of the original domain of the United States west of the Appalachians, 20,500 square miles, about evenly divided between Wisconsin and Michigan, remain, as yet, devoid of settlement. These are tracts still, or recently, covered by dense forests, or of a rocky character containing mineral deposits of an unknown value. Although mining, lumbering, and fishing parties have invaded this region from all points during the past ten years, it is not probable that these lands will, at any near period, contribute appreciably to the grain production of the country.

To the south lie two vast bodies of unsettled territory. Florida contains nearly 21,000 square miles still vacant of population. Much of this region is covered by dense forests and everglades, almost inaccessible to man. Of the remainder, no small part consists of swamps and sandy barrens. Many a decade will pass before these vast spaces on the map of population will be filled.

Far in the south-west, Texas shows 137,000 square miles destitute of inhabitants. Much of this consists of land now unoccupied, solely by reason of the newness of settlement in

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that region. Other vast tracts are destined to afford a field only for a few thousands of herdsmen and cow-boys. Other vast tracts have, so far as known, no adaptation whatever to the wants of civilized man, and must, through an indefinite future, remain the ranging ground of the buffalo and the Apache.

Of the remaining domain of the United States west of the Mississippi and north-west of Texas, about 1,200,000 square miles are at present embraced in the category of unsettled territory, or occupied only by Indians,—viz., in Minnesota, Kansas, and Nebraska, 90,000; in Montana, Dakota, and Wyoming, 355,000; in Oregon, Washington, and Idaho, 188,000; in New Mexico and Colorado, 155,000; in California, Nevada, Utah, and Arizona, 350,000; in the Indian territory, 64,000.

Of this aggregate, one fifth, or about 240,000 square miles, is comprised within Indian reservations. Of the remaining four fifths, how much remains destitute of population purely by reason of the newness of the country and its very recent and partial exploration? how much, on the other hand, by reason of ruggedness and ill adaptation to human wants, is likely to remain unoccupied through a distant future? This is a question which, though the answer must necessarily be vague in the absence of precise data, is yet of such tremendous import to the power and the consequence of our country that it cannot be without interest or profit to consider the matter in the light of our present knowledge.

One great part of the region in question is comprised within the Cordilleran chain of North America—a mighty mass of mountains, unequalled in their totality upon the face of the globe, forming, when seen by the eye that is not bewildered by complexity or the contradiction of individual features, a vast lozenge-shaped figure upon the surface of the continent, bounded by two parallels north and south, and two north-west and south-east sides, the length of each of the four sides being approximately six hundred miles.

Within the giant outlines thus drawn can be counted over and over again, and still many times over, as many peaks, 12,000 feet and upwards, as Europe contains from the Atlantic to the Oural. These mountain ridges shut in numerous valleys, them-

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selves five or six thousand feet above the sea, some of them large enough to form first-class states, which will doubtless become the seats of no inconsiderable populations, while here and there the discovery of rich mineral deposits will cause villages and even cities to be perched eight or ten thousand feet above tide-water; but the great bulk of this mountain region is destined to remain void of settlement through an interminable period, either from ruggedness of surface and barrenness of soil, or from the lack of the moisture necessary for successful agriculture.

These, and the great plains sloping eastward and westward from the outward walls of this mountain fortress, form the "arid lands" which are the subject of a valuable report of Major Powell, comprising, according to his estimate, something more than two fifths of the entire surface of the country. Here the 45 to 60 inches annual precipitation of the Atlantic coast is reduced to 15, and even 10 or fewer, inches of rain-fall a year. Agriculture is absolutely precluded, except upon the single condition of artificial irrigation. To the eastward of the nearly north and south line which bounds the arid lands of the continent lies a zone consisting of vast elevated plains, whose surface offers no obstruction to the movements of population, whose soil is not wholly destitute of the elements of fertility, yet up whose slow incline population shows a great reluctance to climb. This is the region of high maximum temperature and of *scanty* rain-fall, the precipitation of the year ranging from 12 to 28 inches. It constitutes what Powell calls the "sub-humid region," comprising hundreds of thousands of square miles, divided, perhaps not unequally, between good and bad lands. Here agriculture may be carried on, but subject to casualties which make its profitableness very questionable, with the possibility of ultimate loss. Any year may be a good one, but every year will not. Disastrous droughts occur over this zone, more frequently indeed towards the West; yet even on its eastern border, in Kansas, Nebraska, and Dakota, the constant imminence of a partial or a total failure of crops makes the occupation of these lands a very doubtful experiment. With a proper revision of our riparian laws, and with improvements reasonably to be anticipated in the art of irrigation, such of

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these lands as lie near the streams may become the field of a highly successful agriculture. Those for which the supply in the streams is not sufficient will be cultivated at a risk of loss which the owners of small lots cannot afford to take. Possibly among the innovations of the coming age may be cultivating companies, which, possessing large capital, may be able to average good years and bad, as the poor single cultivator cannot, and may thus keep extensive portions of this zone in crops: but this must be regarded as very doubtful. Many well-informed persons think that fully as much of this region is already improved as is likely to be maintained in cultivation, and, indeed, that a refluent wave of population from the extreme frontier is not improbable.

It thus appears that, notwithstanding the imposing total of 1,400,000 square miles of still unsettled territory, the amount of land available for occupation for ordinary agriculture is not large.

The public land commission, in their report of 1880, say,— "It was estimated June 30, 1879, that (exclusive of certain lands in Southern states) of lands over which the survey and disposition laws had been extended, lying in the West, the United States did not own, of arable agricultural public lands, which could be cultivated without irrigation or other artificial appliances, more than the area of the present state of Ohio, viz., 25,576,960 acres."

The quantity of lands taken up in the arable region during the year ending June 30, 1880, was about 7,000,000 acres. The commission, therefore, reach the startling conclusion that, at the same rate of absorption, the arable lands so situated will all be taken up within three years, or by June 30, 1883. Of the character and quantity of the public domain remaining June 30, 1880, the commission make the following estimates in acres:

| | |
|---|---|
| 1. Timber lands, . . . . . | 85,000,000 |
| 2. Coal lands (to be largely increased by better classification and survey), . . . . . | 5,529,970 |
| 3. Lands containing known mineral deposits of value (subject to a large increase by new discoveries), . . . . . | 64,800,000 |



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| | |
|---|---|
| 4. Arable lands remaining in Northern states and territories, over which United States laws, as to survey and disposition, have been extended, | 17,800,000 |
| 5. Lands in Southern states, surveyed and unsurveyed, . . . . . | 25,585,641 |
| 6. Irrigable lands which can be taken under desert land act, say one twentieth of the remainder, being the lands which can be irrigated from the present water supply, . . . . | 30,000,000 |
| 7. The remainder—pasturage, grazing, desert, and all other lands useless for agriculture by reason of altitude, lack of water or soil, including balance of lands likely to be segregated for private land grants, etc., still unsatisfied, and Indian and military reservations, including, also, unsurveyed area of Indian territory, viz., 17,150,250 acres, . . . . . | 565,701,222 |

It is, indeed, an astonishing announcement that the public land system, so far as relates to agricultural settlers, has virtually come to an end; that the homestead and preëmption acts are practically exhausted of their contents.

During the past twelve months 600,000 immigrants have arrived upon our shores, and there was a free farm for all who chose to take it. The immigrants of another year, and perhaps of still another, are provided for; but what is to become of the millions whom Europe is ready to pour upon our shores? It will scarcely seem the United States any more, when we cannot boast of our readiness to give a farm to every comer. It is a question well worthy of careful consideration what effect the loss of this free—by which I mean gratuitous—resort to the land will have upon the conditions of manufacturing among us, and upon the character of our industrial classes.

With reference to our present inquiry, however, namely, the possibility of keeping up our traditional methods of agriculture and maintaining the volume of our food exports, the situation described is not so serious as might be thought.

Vast quantities of land which have passed out of the hands of the government, through patents to states, to schools and

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colleges, to railways, etc., have not yet come under cultivation and occupation. Other large quantities are in the hands of private owners, who have never cultivated them, or, at least, have not done so *bona fide*, having taken them speculatively,* and kept up a merely formal compliance with the requirements of the law. Considerable additions to the public lands may also be expected from the reduction of Indian reservations, as the tribes concerned take up small lots in severalty, and cede the remainder to the United States. Some parts of the extensive mineral and coal lands, withdrawn from the scope of the general land law, will unquestionably be found to have an agricultural value; and the surface will be worked for one kind of wealth while the recesses beneath are searched for another.

From all these sources additions will doubtless be made to the body of land available for occupation, though not under the homestead and preëmption acts. It is, moreover, not improbable that the lands of the sub-humid region, large parts of which, on the eastern side of this great longitudinal belt, have already been taken up, and are under cultivation with varying success, large parts of which still remain open to settlement, may be found to have a somewhat wider adaptation to agricultural purposes than is assigned them by Major Powell. Culture, if it do not increase the annual precipitation, will secure a more equal distribution of moisture in the soil; while the introduction of mixed farming, the advantages of which are now so admirably illustrated in New York state, will, while perhaps reducing the maximum profits of good years, protect the cultivator in some measure from the disasters of dry seasons, inasmuch as the periods of planting and harvesting differ widely in the case of the several crops which would probably form the subject-matter of such cultivation in western Kansas, Nebraska, and Dakota.

There remains, moreover, to be brought into account the body of lands in the arid region fairly subject to irrigation, which may be taken up under the desert land act, and for which a sufficient amount of water is now found in the streams. The aggregate extent of these lands is stated by the public land

*It appears by the report of the public land commission that it is possible for one person, under existing laws, to take up, in all, 1,120 acres, under one sort of title or another.

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commission at 30,000,000 acres. There is reason to believe that large portions of this will soon, and all of it eventually, be made productive by systems of reservoirs and irrigating canals.

As the joint effect of all these considerations, I reach the conclusion that it is not unreasonable to suppose that the extent of lands actually occupied for the production of exportable crops may go on increasing to the close of the century. Supposing the amount of arable lands in the possession of individuals disposed to cultivate them to attain, at that date, its maximum, the further question arises, What term may then be allowed us, as a people, for continuing our traditional system of cropping, with something like the degree of immediate profit to the owner of the soil (for, let it be borne in mind, it has never been the greed of occupiers who were not owners which has led to the steady pursuit of this system in the past) which has heretofore attended it?

Any answer that might be given to this question would, of necessity, be very largely conjectural. What with improvements in agricultural methods and appliances, which are certain to be sooner apprehended and more widely used here than anywhere else in the world; what with the rapid extension of our railway lines; what with the intensification of culture, either through the subdivision of existing landed properties, or through the multiplication of hired hands upon the larger farms, I see no reason to doubt that throughout the first half of the coming century the production of the chief staples of American agriculture might go or increasing, not only absolutely, but even *per capita* of population, as it has increased from 1800 to the present time, new lands, now nominally occupied, but not cultivated up to a half, a quarter, or a tithe of their capability, coming in not only to make good the loss by exhaustion of lands now of full bearing virtue, but to allow the increase of our population up to the gigantic total of a hundred or a hundred and twenty-five millions, without impairing our ability to export as largely and as variously of agricultural produce as to-day.

But there is even a better prospect for our agriculture than this. The powerful reasons, economical and political, which have in the past justified the cultivation of the soil, in some degree at the expense of future generations, have mainly ceased

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to exist, and will soon disappear altogether. The country, in its arable parts, is settled, and the line of population now rests near the base of the great sterile mountains which occupy so large a portion of the continent. The accumulations of capital out of the profits of American agriculture, under the system of cropping that has been described, have been so great at the North and West as even to keep ahead of the occasions for their remunerative investment, as is shown by a falling rate of interest; and there is no longer any reason to be found in the scarcity of capital for postponing the systematic cultivation of the soil. Lastly, the political reasons which made the early settlement of the country so urgently desirable are no longer of force.

With adequate labor power and capital power, and with all national exigencies satisfied, the time has come when economical and political considerations alike demand that the soil bequeathed to this generation, or opened up by its own exertions, shall hereafter be deemed and held as a fund in trust for the American people through all time to come, not to be diminished or impaired for the selfish enjoyment of the immediate possessors.

Down to this time our apparently wasteful culture has, as I have sought to show, been the true economy of the national strength; our apparent abuse of the capital fund of the country has, in fact, effected the highest possible improvement of the public patrimony. Thirty-eight noble states, in an indissoluble union, are the ample justification of this policy. Their schoolhouses and churches, their shops and factories, their roads and bridges, their railways and warehouses, are the fruits of the characteristic American agriculture of the past.

But from a time not far distant, if indeed it has not already arrived, a continuance in this policy will be, not the improvement of our patrimony, but the impoverishment of our posterity. There will be all the difference between the past and the future, in this respect, morally, economically, and patriotically considered, which there is between the act of the strong, courageous, hopeful young man, who puts a mortgage on his new farm that he may stock it and equip it for a higher productiveness, and the act of the self-indulgent man of middle life who encumbers his estate for the purposes of personal consumption.

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# STICK TO NEW HAMPSHIRE.

"THERE'S NO PLACE LIKE HOME."

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The * indicates that the state is one of nineteen oldest in settlement, including District of Columbia. † Nine states second in age. ‡ Five states third in age. § Six states fourth in age.

The problem of long life—or the chances of reaching eighty years of age and upward—in the several portions of the United States, given by sex, in classes of native white inhabitants, colored (including negroes, Chinese, and Indians), and the foreign-born, separately, and in the aggregate of population, as per census of 1880, is shown below. The items, given by states, and groups of states, are as follows:

NEW HAMPSHIRE.*

| | | | | |
|---|---|---|---|---|
| Native white males, | *one* in | 80.8 | of population | in its class. |
| " females, | " | 58.4 | " | " |
| Colored males, | " | 194.5 | " | " |
| " females, | " | 124.5 | " | " |
| Foreign-born males, | " | 193.3 | " | " |
| " females, | " | 170.6 | " | " |

Pop. of state, 346,991; persons 80 years old, 4,694; average of whole population, one in **73.9**

VERMONT.*

| | | | | |
|---|---|---|---|---|
| Native white males, | *one* in | 87.0 | of population | in its class. |
| " females, | " | 77.2 | " | " |
| Colored males, | " | 82.1 | " | " |
| " females, | " | 82.1 | " | " |
| Foreign-born males, | " | 72.6 | " | " |
| " females, | " | 86.7 | " | " |

Pop. of state, 332,286; persons 80 years old, 4,081; average of whole population, one in **81.4**

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MAINE.*

| | | | | |
|---|---|---|---|---|
| Native white males, | *one* in | 99.7 | of population | in its class. |
| " females, | " | 77.5 | " | " |
| Colored males, | " | 120.5 | " | " |
| " females, | " | 62.4 | " | " |
| Foreign-born males, | " | 99.4 | " | " |
| " females, | " | 109.4 | " | " |

Pop. of state, 648,936; persons 80 years old, 7,333; average of whole population, one in **85.9**

CONNECTICUT.*

| | | | | |
|---|---|---|---|---|
| Native white males, | *one* in | 129.7 | of population | in its class. |
| " females, | " | 82.4 | " | " |
| Colored males, | " | 156.8 | " | " |
| " females, | " | 102.1 | " | " |
| Foreign-born males, | " | 181.2 | " | " |
| " females, | " | 159.1 | " | " |

Pop. of state, 622,700; persons 80 years old, 5,655; average of whole population, one in **110.1**

MASSACHUSETTS.*

| | | | | |
|---|---|---|---|---|
| Native white males, | *one* in | 160.9 | of population | in its class. |
| " females, | " | 101.1 | " | " |
| Colored males, | " | 189.2 | " | " |
| " females, | " | 123.0 | " | " |
| Foreign-born males, | " | 196.8 | " | " |
| " females, | " | 142.8 | " | " |

Pop. of state, 1,783,085; persons 80 years old, 13,525; average of whole population, one in **131.8**

RHODE ISLAND.*

| | | | | |
|---|---|---|---|---|
| Native white males, | *one* in | 179.4 | of population | in its class. |
| " females, | " | 91.9 | " | " |
| Colored males, | " | 232.0 | " | " |
| " females, | " | 105.0 | " | " |

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Foreign-born males, *one* in 215.9 of population in its class.
" females, " 174.0 " "
Pop. of state, 276,531; persons
80 years old, 2,055; average
of whole population, one in **134.6**

GROUP OF SIX NEW ENGLAND STATES.

Population, 4,010,529; persons
80 years old, 37,343; average,
one in **107.4**

NEW YORK.*

Native white males, *one* in 193.2 of population in its class.
" females, " 164.6 " "
Colored males, " 168.6 " "
" females, " 113.2 " "
Foreign-born males, " 143.4 " "
" females, " 113.7 " "
Pop. of state, 5,082,871; persons
80 years old, 31,473; average
of whole population, one in **161.5**

PENNSYLVANIA.*

Native white males, *one* in 286.6 of population in its class.
" females, " 212.0 " "
Colored males, " 177.1 " "
" females, " 126.2 " "
Foreign-born males, " 124.5 " "
" females, " 98.1 " "
Pop. of state, 4,282,891; persons
80 years old, 20,735; average
of whole population, one in **206.5**

NEW JERSEY.*

Native white males, *one* in 274.6 of population in its class.
" females, " 181.3 " "
Colored males, " 173.2 " "
" females, " 123.0 " "

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Foreign-born males, *one* in 230.0 of population in its class.
" females, " 160.6 " "
Pop. of state, 1,131,116; persons 80 years old, 5,438; average of whole population, one in **208.0**

GROUP OF THREE MIDDLE STATES.

Population, 10,496,878; persons 80 years old, 57,646; average, one in **182.0**

VIRGINIA.*

Native white males, *one* in 226.0 of population in its class.
" females, " 179.6 " "
Colored males, " 187.1 " "
" females, " 145.1 " "
Foreign-born males, " 139.1 " "
" females, " 106.3 " "
Pop. of state, 1,512,565; persons 80 years old, 8,315; average of whole population, one in **181.9**

NORTH CAROLINA.*

Native white males, *one* in 224.9 of population in its class.
" females, " 176.1 " "
Colored males, " 244.6 " "
" females, " 164.1 " "
Foreign-born males, " 71.9 " "
" females, " 42.6 " "
Pop. of state, 1,399,750; persons 80 years old, 7,168; average of whole population, one in **195.3**

DELAWARE.*

Native white males, *one* in 331.0 of population in its class.
" females, " 192.8 " "
Colored males, " 225.9 " "
" females, " 127.6 " "

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Foreign-born males, *one* in 91.1 of population in its class.
" females, " 69.8 " "
Pop. of state, 146,608; persons
80 years old, 733; average
of whole population, one in **200.0**

SOUTH CAROLINA.*

Native white males, *one* in 266.0 of population in its class.
" females, " 198.5 " "
Colored males, " 223.9 " "
" females, " 173.7 " "
Foreign-born males, " 85.1 " "
" females, " 63.9 " "
Pop. of state, 995,577; persons
80 years old, 4,887; average
of whole population, one in **203.7**

MARYLAND.*

Native white males, *one* in 356.7 of population in its class.
" females, " 243.0 " "
Colored males, " 253.1 " "
" females, " 137.4 " "
Foreign-born males " 128.9 " "
" females, " 87.9 " "
Pop. of state, 934,943; persons
80 years old, 4,276; average
of whole population, one in **218.6**

GEORGIA.*

Native white males, *one* in 259.7 of population in its class.
" females, " 240.2 " "
Colored males, " 253.1 " "
" females, " 177.9 " "
Foreign-born males, " 153.4 " "
" females, " 112.2 " "
Pop. of state, 1,542,188; persons
80 years old, 6,786; average
of whole population, one in **227.2**

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DISTRICT OF COLUMBIA.*

| | | | | |
|---|---|---|---|---|
| Native white males, | *one* in | 250.9 | of population | in its class. |
| " females, | " | 267.1 | " | " |
| Colored males, | " | 247.7 | " | " |
| " females, | " | 146.9 | " | " |
| Foreign-born males, | " | 211.0 | " | " |
| " females, | " | 115.7 | " | " |

Pop. of dist., 177,624; persons 80 years old, 757; average of whole population, one in **234.6**

GROUP OF SIX SOUTH ATLANTIC STATES.

Population, 6,709,247; persons 80 years old, 17,330; average one in **203.8**

LOUISIANA.*

| | | | | |
|---|---|---|---|---|
| Native white males, | *one* in | 746.3 | of population | of its class. |
| " females, | " | 531.4 | " | " |
| Colored males, | " | 173.3 | " | " |
| " females, | " | 151.4 | " | " |
| Foreign-born males, | " | 207.3 | " | " |
| " females, | " | 121.6 | " | " |

Pop. of state, 939,946; persons 80 years old, 3,988; average of whole population, one in **235.7**

ALABAMA.†

| | | | | |
|---|---|---|---|---|
| Native white males, | *one* in | 294.0 | of population | in its class. |
| " females, | " | 292.8 | " | " |
| Colored males, | " | 243.7 | " | " |
| " females, | " | 191.8 | " | " |
| Foreign-born males, | " | 166.2 | " | " |
| " females, | " | 102.9 | " | " |

Pop. of state, 1,262,505; persons 80 years old, 5,097; average of whole population, one in **247.7**

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MISSISSIPPI.†

| | | | | |
|---|---|---|---|---|
| Native white males, | *one* in | 416.8 | of population | in its class. |
| " females, | " | 398.6 | " | " |
| Colored males, | " | 255.2 | " | " |
| " females, | " | 197.4 | " | " |
| Foreign-born males, | " | 261.8 | " | " |
| " females, | " | 106.2 | " | " |

Pop. of state, 1,131,597; persons 80 years old, 4,137; average of whole population, one in **273.5**

FLORIDA.*

| | | | | |
|---|---|---|---|---|
| Native white males, | *one* in | 512.6 | of population | in its class. |
| " females, | " | 469.5 | " | " |
| Colored males, | " | 224.8 | " | " |
| " females, | " | 202.9 | " | " |
| Foreign-born males, | " | 268.6 | " | " |
| " females, | " | 136.4 | " | " |

Pop. of state, 269,493; persons 80 years old, 910; average of whole population, one in **296.1**

TEXAS.†

| | | | | |
|---|---|---|---|---|
| Native white males, | *one* in | 918.9 | of population | in its class. |
| " females, | " | 859.1 | " | " |
| Colored males, | " | 299.5 | " | " |
| " females, | " | 227.8 | " | " |
| Foreign-born males, | " | 280.8 | " | " |
| " females, | " | 227.8 | " | " |

Pop. of state, 1,591,749; persons 80 years old, 3,198; average of whole population, one in **497.7**

GROUP OF FIVE GULF STATES.

Population, 5,195,290; persons 80 years old, 17,330; average, one in . . . **299.8**

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WEST VIRGINIA.*

| | | | |
|---|---|---|---|
| Native white males, | *one* in 267.7 | of population | in its class. |
| " females, | " 252.4 | " | " |
| Colored males, | " 201.5 | " | " |
| " females, | " 151.4 | " | " |
| Foreign-born males, | " 91.3 | " | " |
| " females, | " 103.4 | " | " |

Pop. of state, 618,457; persons 80 years old, 2,547; average of whole population, one in **242.8**

KENTUCKY.†

| | | | |
|---|---|---|---|
| Native white males, | *one* in 317.8 | of population | in its class. |
| " females, | " 292.9 | " | " |
| Colored males, | " 250.1 | " | " |
| " females, | " 156.0 | " | " |
| Foreign-born males, | " 151.9 | " | " |
| " females, | " 109.3 | " | " |

Pop. of state, 1,648,690; persons 80 years old, 6,199; average of whole population, one in **266.0**

TENNESSEE.†

| | | | |
|---|---|---|---|
| Native white males, | *one* in 312.7 | of population | in its class. |
| " females, | " 261.7 | " | " |
| Colored males, | " 300.0 | " | " |
| " females, | " 194.7 | " | " |
| Foreign-born males, | " 266.2 | " | " |
| " females, | " 110.6 | " | " |

Pop. of state, 1,542,359; persons 80 years old, 5,708; average of whole population, one in **270.2**

GROUP OF THREE EAST MISSISSIPPI STATES.

Population, 3,809,506; persons 80 years old, 14,454; average, one in . . . **263.6**

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OHIO.†

| | | | |
|---|---|---|---|
| Native white males, | *one* in 254.0 | of population | in its class. |
| " females | " 232.6 | " | " |
| Colored males, | " 214.3 | " | " |
| " females, | " 151.7 | " | " |
| Foreign-born males, | " 106.3 | " | " |
| " females, | " 93.5 | " | " |

Pop. of state, 3,198,062 ; persons 80 years old, 15,606 ; average of whole population, one in **204.9**

WISCONSIN.‡

| | | | |
|---|---|---|---|
| Native white males, | *one* in 411.3 | of population | in its class. |
| " females, | " 432.6 | " | " |
| Colored males, | " 183.5 | " | " |
| " females, | " 98.5 | " | " |
| Foreign-born males, | " 116.1 | " | " |
| " females, | " 106.4 | " | " |

Pop. of state, 1,315,497 ; persons 80 years old, 5,825 ; average of whole population, one in **225.8**

MICHIGAN.‡

| | | | |
|---|---|---|---|
| Native white males, | *one* in 307.7 | of population | in its class. |
| " females, | " 320.4 | " | " |
| Colored males, | " 146.3 | " | " |
| " females, | " 416.3 | " | " |
| Foreign-born males, | " 184.5 | " | " |
| " females, | " 171.8 | " | " |

Pop. of state, 1,636,937 ; persons 80 years old, 6,248 ; average of whole population, one in **262.0**

INDIANA.†

| | | | |
|---|---|---|---|
| Native white males, | *one* in 393.7 | of population | in its class. |
| " females, | " 372.5 | " | " |
| Colored males, | " 253.1 | " | " |
| " females, | " 175.2 | " | " |

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Foreign-born males, *one* in 119.7 of population in its class.
" females, " 108.3 " "
Pop. of state, 1,978,301 ; persons
80 years old, 6,135 ; average
of whole population, one in **322.5**

ILLINOIS.†

Native white males, *one* in 498.6 of population in its class.
" females, " 437.5 " "
Colored males, " 330.6 " "
" females, " 168.6 " "
Foreign-born males, " 191.5 " "
" females, " 156.6 " "
Pop. of state, 3,077,871 ; persons
80 years old, 8,820 ; average
of whole population, one in **349.0**

GROUP OF FIVE LAKE STATES.

Population, 11,206,668 ; persons
80 years old, 42,634 ; average
one in . . . . **262.9**

IOWA.‡

Native white males, *one* in 443.6 of population in its class.
" females, " 473.9 " "
Colored males, " 340.0 " "
" females, " 207.9 " "
Foreign-born males, " 146.2 " "
" females " 134.0 " "
Pop. of state, 1,624,615 ; persons
80 years old, 4,853 ; average
of whole population, one in **334.8**

MINNESOTA.§

Native white males, *one* in 752.6 of population in its class.
" females, " 680.7 " "
Colored males, " 345.6 " "
" females, " 129.6 " "

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Foreign-born males, *one* in 204.6 of population in its class.
" females, " 164.0 " "
Pop. of state, 780,773; persons 80 years old, 2,179; average of whole population, one in **658.3**

MISSOURI.†

Native white males, *one* in 608.9 of population in its class.
" females, " 594.4 " "
Colored males, " 330.1 " "
" females, " 173.5 " "
Foreign-born males, " 238.5 " "
" females, " 156.9 " "
Pop. of state, 2,168,380; persons 80 years old, 4,733; average of whole population, one in **458.1**

ARKANSAS.‡

Native white males, *one* in 750.0 of population in its class.
" females, " 777.3 " "
Colored males, " 351.5 " "
" females, " 241.0 " "
Foreign-born males, " 448.8 " "
" females, " 427.7 " "
Pop. of state, 802,525; persons 80 years old, 1,520; average of whole population, one in **528.1**

NEBRASKA.§

Native white males, *one* in 1,021.8 of population in its class.
" females, " 1,048.5 " "
Colored males, " 713.0 " "
" females, " 606.0 " "
Foreign-born males, " 352.3 " "
" females, " 322.3 " "
Pop. of state, 452,402; persons 80 years old, 633; average of whole population, one in **713.1**



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KANSAS.§

| | | | | |
|---|---|---|---|---|
| Native white males, | *one* in | 1,020.6 | of population | in its class. |
| " females, | " | 949.5 | " | " |
| Colored males, | " | 309.3 | " | " |
| " females, | " | 201.5 | " | " |
| Foreign-born males, | " | 351.3 | " | " |
| " females, | " | 314.4 | " | " |

Pop. of state, 996,096; persons 80 years old, 1,361; average of whole population, one in **731.9**

COLORADO.§

| | | | | |
|---|---|---|---|---|
| Native white males, | *one* in | 1,482.7 | of population | in its class. |
| " females, | " | 949.4 | " | " |
| Colored males, | " | 2,090.0 | " | " |
| " females, | " | 370.3 | " | " |
| Foreign-born males, | " | 1,459.0 | " | " |
| " females, | " | 453.0 | " | " |

Pop. in state, 194,327; persons 80 years old, 169; average of whole population, one in **1150.0**

GROUP OF SEVEN WEST MISSISSIPPI STATES.

Population, 7,019,118; persons 80 years old, 15,448; average, one in . . . **453.7**

CALIFORNIA.‡

| | | | | |
|---|---|---|---|---|
| Native white males, | *one* in | 837.2 | of population | in its class. |
| " females, | " | 776.1 | " | " |
| Colored males, | " | 491.8 | " | " |
| " females, | " | 95.3 | " | " |
| Foreign-born males, | " | 395.9 | " | " |
| " females, | " | 252.8 | " | " |

Pop. of state, 864,694; persons 80 years old, 1,665; average of whole population, one in **519.3**

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OREGON.§

| | | | | |
|---|---|---|---|---|
| Native white males, | *one* in | 558.3 | of population | in its class. |
| " females, | " | 598.2 | " | " |
| Colored males, | " | 1,741.0 | " | " |
| " females, | " | 138.5 | " | " |
| Foreign-born males, | " | 527.6 | " | " |
| " females, | " | 236.8 | " | " |

Pop. of state, 174,768; persons 80 years old, 316; average of whole population, one in **542.2**

NEVADA.§

| | | | | |
|---|---|---|---|---|
| Native white males, | *one* in | 3,343.3 | of population | in its class. |
| " females, | " | 2,215.0 | " | " |
| Colored males, | " | 150.0 | " | " |
| " females, | " | 194.4 | " | " |
| Foreign-born males, | " | 1,499.9 | " | " |
| " females, | " | 744.0 | " | " |

Pop. of state, 62,266; persons 80 years old, 51; average of whole population, one in **1220.9**

GROUP OF THREE PACIFIC STATES.

Population of all, 1,101,728; persons 80 years old, 2,032; average, one in **542.3**

New Mexico, an old settled Spanish territory, of climate said to be remarkable for health and longevity, has one person 80 years old to every 217 of its population.

The group of eight territories, including New Mexico, has an average of one person 80 years old in 479 of population.

The population of the United States, by the last census, was 50,155,983, with 221,076 persons 80 years old and upward. The average of persons 80 years old in the whole country is one in 226.87.

The lease of longest life pertains to New Hampshire, Vermont, and Maine. The hill country is the section for long life. Flee to the mountains for health and longevity! New Hampshire heads the column.

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## POPULATION OF NEW HAMPSHIRE BY SPECIFIED AGE, SEX, RACE, AND GENERAL NATIVITY, ETC., 1880.

| Ages. | All Classes. | | | White. | | | | | | | | | Colored (including Chinese, Japanese, and civilized Indians). | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Native. | | | Foreign-born. | | | | | |
| | Total. | Male. | Female. | Total. | Male. | Female. | Total. | Male. | Fem. | Total. | Male. | Fem. | Total. | Male. | Female. |
| Totals..... | 346,991 | 170,526 | 176,465 | 346,229 | 170,137 | 176,092 | 299,995 | 147,909 | 152,086 | 46,234 | 22,228 | 24,006 | 762 | 389 | 373 |
| Under 1 year..... | 6,141 | 3,137 | 3,004 | 6,124 | 3,132 | 2,992 | 6,010 | 3,070 | 2,940 | 114 | 62 | 52 | 17 | 5 | 12 |
| 1 year..... | 5,690 | 2,917 | 2,773 | 5,673 | 2,908 | 2,765 | 5,475 | 2,804 | 2,671 | 198 | 104 | 94 | 17 | 9 | 8 |
| 2 years..... | 6,224 | 3,194 | 3,030 | 6,207 | 3,186 | 3,021 | 5,940 | 3,065 | 2,875 | 267 | 121 | 146 | 17 | 8 | 9 |
| 3 years..... | 6,228 | 3,084 | 3,144 | 6,205 | 3,070 | 3,135 | 5,857 | 2,909 | 2,948 | 348 | 161 | 187 | 23 | 14 | 9 |
| 4 years..... | 6,290 | 3,172 | 3,118 | 6,272 | 3,164 | 3,108 | 5,906 | 2,987 | 2,919 | 366 | 177 | 189 | 18 | 8 | 10 |
| Under 5 years... | 30,573 | 15,504 | 15,069 | 30,481 | 15,460 | 15,021 | 29,188 | 14,835 | 14,353 | 1,293 | 625 | 668 | 92 | 44 | 48 |
| 5 years..... | 6,151 | 3,093 | 3,058 | 6,135 | 3,082 | 3,053 | 5,746 | 2,880 | 2,866 | 389 | 202 | 187 | 16 | 11 | 5 |
| 6 years..... | 6,254 | 3,099 | 3,155 | 6,230 | 3,091 | 3,148 | 5,855 | 2,899 | 2,956 | 384 | 192 | 192 | 15 | 8 | 7 |
| 7 years..... | 6,002 | 3,002 | 3,000 | 5,986 | 2,991 | 2,995 | 5,565 | 2,778 | 2,787 | 421 | 213 | 208 | 16 | 11 | 5 |
| 8 years..... | 6,096 | 3,103 | 2,993 | 6,085 | 3,097 | 2,988 | 5,583 | 2,888 | 2,745 | 502 | 259 | 243 | 11 | 6 | 5 |
| 9 years..... | 5,727 | 2,918 | 2,809 | 5,709 | 2,911 | 2,798 | 5,247 | 2,672 | 2,575 | 462 | 239 | 223 | 18 | 7 | 11 |
| 5 to 9 years..... | 30,230 | 15,215 | 15,015 | 30,154 | 15,172 | 14,982 | 27,996 | 14,067 | 13,929 | 2,158 | 1,105 | 1,053 | 76 | 43 | 33. |
| 10 years..... | 6,122 | 3,123 | 2,999 | 6,108 | 3,117 | 2,991 | 5,567 | 2,845 | 2,722 | 541 | 272 | 269 | 14 | 6 | 8 |
| 11 years..... | 5,878 | 2,877 | 3,001 | 5,866 | 2,872 | 2 994 | 5,342 | 2,628 | 2,714 | 524 | 244 | 280 | 12 | 5 | 7 |
| 12 years..... | 6.402 | 3,295 | 3,107 | 6,390 | 3,289 | 3,101 | 5.750 | 2,959 | 2,791 | 640 | 330 | 310 | 12 | 6 | 6 |
| 13 years..... | 6,187 | 3,110 | 3,077 | 6,175 | 3,106 | 3,069 | 5,539 | 2,820 | 2,719 | 636 | 286 | 350 | 12 | 4 | 8 |
| 14 years..... | 6.080 | 3,100 | 2,980 | 6,066 | 3,093 | 2,973 | 5,387 | 2,763 | 2,574 | 729 | 330 | 399 | 14 | 7 | 7 |
| 10 to 14 years... | 30,669 | 15,505 | 15,164 | 30,605 | 15,477 | 15,128 | 27,535 | 14,015 | 13,520 | 3,070 | 1,462 | 1,608 | 64 | 28 | 36 |

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| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 15 years..... | 5,980 | 2,896 | 3,084 | 5,973 | 2,893 | 3,080 | 5,046 | 2,522 | 2,524 | 927 | 371 | 556 | 7 | 3 | 4 |
| 16 years..... | 6,061 | 2,923 | 3,138 | 6,048 | 2,919 | 3,129 | 5,021 | 2,488 | 2,533 | 1,027 | 431 | 596 | 13 | 4 | 9 |
| 17 years..... | 6,180 | 3,033 | 3,147 | 6,164 | 3,028 | 3,136 | 5,146 | 2,635 | 2,511 | 1,018 | 393 | 625 | 16 | 5 | 11 |
| 18 years..... | 7,098 | 3,377 | 3,721 | 7,087 | 3,373 | 3,714 | 5,760 | 2,823 | 2,937 | 1,327 | 550 | 777 | 11 | 4 | 7 |
| 19 years..... | 6,736 | 3,394 | 3,342 | 6,721 | 3,334 | 3,337 | 5,499 | 2,820 | 2,679 | 1,222 | 564 | 658 | 15 | 10 | 5 |
| 15 to 19 years... | 32,055 | 15,623 | 16,432 | 31,993 | 15,597 | 16,396 | 26,472 | 13,288 | 13,184 | 5,521 | 2,309 | 3,212 | 62 | 26 | 36 |
| 20 years..... | 7,310 | 3,541 | 3,769 | 7,290 | 3,530 | 3,760 | 5,874 | 2,914 | 2,960 | 1,416 | 616 | 800 | 20 | 11 | 9 |
| 21 years..... | 6,764 | 3,475 | 3,289 | 6,746 | 3,466 | 3,280 | 5,667 | 2,991 | 2,676 | 1,079 | 475 | 604 | 18 | 9 | 9 |
| 22 years..... | 7,205 | 3,465 | 3,740 | 7,194 | 3,459 | 3,735 | 5,888 | 2,841 | 3,047 | 1,306 | 618 | 688 | 11 | 6 | 5 |
| 23 years..... | 6,732 | 3,367 | 3,365 | 6,718 | 3,360 | 3,358 | 5,601 | 2,847 | 2,754 | 1,117 | 513 | 604 | 14 | 7 | 7 |
| 24 years..... | 6,740 | 3,419 | 3,321 | 6,719 | 3,413 | 3,306 | 5,539 | 2,854 | 2,685 | 1,180 | 559 | 621 | 21 | 6 | 15 |
| 20 to 24 years... | 34,751 | 17,267 | 17,484 | 34,667 | 17,228 | 17,439 | 28,569 | 14,447 | 14,122 | 6,098 | 2,781 | 3,317 | 84 | 39 | 45 |
| 25 years..... | 6,538 | 3,162 | 3,371 | 6,517 | 3,150 | 3,367 | 5,280 | 2,551 | 2,729 | 1,237 | 599 | 638 | 16 | 12 | 4 |
| 26 years..... | 5,806 | 2,861 | 2,945 | 5,782 | 2,849 | 2,933 | 4,766 | 2,340 | 2,426 | 1,016 | 509 | 507 | 24 | 12 | 12 |
| 27 years..... | 5,433 | 2,768 | 2,665 | 5,419 | 2,759 | 2,660 | 4,499 | 2,285 | 2,214 | 920 | 474 | 446 | 14 | 9 | 5 |
| 28 years..... | 5,887 | 2,927 | 2,960 | 5,874 | 2,919 | 2,955 | 4,794 | 2,377 | 2,417 | 1,080 | 542 | 538 | 13 | 8 | 5 |
| 29 years..... | 4,842 | 2,465 | 2,377 | 4,826 | 2,455 | 2,371 | 4,091 | 2,086 | 2,005 | 785 | 369 | 366 | 16 | 10 | 6 |
| 25 to 29 years... | 28,501 | 14,183 | 14,318 | 28,418 | 14,132 | 14,286 | 23,430 | 11,639 | 11,791 | 4,988 | 2,493 | 2,495 | 83 | 51 | 32 |
| 30 years..... | 6,423 | 3,155 | 3,268 | 6,397 | 3,140 | 3,257 | 4,932 | 2,406 | 2,526 | 1,465 | 734 | 731 | 26 | 15 | 11 |
| 31 years..... | 3,929 | 1,968 | 1,961 | 3,923 | 1,966 | 1,957 | 3,413 | 1,689 | 1,724 | 510 | 277 | 233 | 6 | 2 | 4 |
| 32 years..... | 4,845 | 2,373 | 2,472 | 4,835 | 2 367 | 2,468 | 3,961 | 1,898 | 2,063 | 874 | 469 | 405 | 10 | 6 | 4 |
| 33 years..... | 4,463 | 2,194 | 2,269 | 4,451 | 2,184 | 2.267 | 3,736 | 1,822 | 1,914 | 715 | 362 | 353 | 12 | 10 | 2 |
| 34 years..... | 4,314 | 2,101 | 2,213 | 4,310 | 2,101 | 2,209 | 3,549 | 1,711 | 1,838 | 761 | 390 | 371 | 4 | ..... | 4 |
| 30 to 34 years... | 23,974 | 11,791 | 12,183 | 23,916 | 11,758 | 12,158 | 19,591 | 9,526 | 10,065 | 4,325 | 2,232 | 2,093 | 58 | 33 | 25 |
| 35 years..... | 5,527 | 2,729 | 2,798 | 5,514 | 2,721 | 2,793 | 4,151 | 2,029 | 2,122 | 1,363 | 692 | 671 | 13 | 8 | 5 |
| 36 years..... | 4,460 | 2,069 | 2,391 | 4,453 | 2,065 | 2,388 | 3,680 | 1,661 | 2,019 | 773 | 404 | 369 | 7 | 4 | 3 |
| 37 years..... | 4,148 | 1,975 | 2,173 | 4,140 | 1,972 | 2,168 | 3,464 | 1,621 | 1,843 | 686 | 351 | 335 | 8 | 3 | 5 |
| 38 years..... | 4,572 | 2,177 | 2,395 | 4,561 | 2,171 | 2,390 | 3,686 | 1,779 | 1,907 | 875 | 392 | 483 | 11 | 6 | 5 |
| 39 years..... | 3,851 | 1,833 | 2,018 | 3,842 | 1,826 | 2,016 | 3,276 | 1,576 | 1,700 | 566 | 250 | 316 | 9 | 7 | 2 |
| 35 to 39 years... | 22,558 | 10,783 | 11,775 | 22,510 | 10,755 | 11,755 | 18,247 | 8,666 | 9,581 | 4,263 | 2,089 | 2,174 | 48 | 28 | 20 |

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POPULATION OF NEW HAMPSHIRE BY SPECIFIED AGE, SEX, RACE, AND GENERAL NATIVITY, ETC., 1880.—*Continued.*

| Ages. | ALL CLASSES. | | | WHITE. | | | | | | | | | COLORED (including Chinese, Japanese, and civilized Indians). | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Native. | | | Foreign-born. | | | | | |
| | Total. | Male. | Female. | Total. | Male. | Female. | Total. | Male. | Fem. | Total. | Male. | Fem. | Total. | Male. | Female. |
| 40 years | 5,732 | 2,650 | 3,082 | 5,715 | 2,643 | 3,072 | 4,172 | 1,914 | 2,258 | 1,543 | 729 | 814 | 17 | 7 | 10 |
| 41 years | 3,150 | 1,490 | 1,660 | 3,144 | 1,487 | 1,657 | 2,754 | 1,300 | 1,454 | 390 | 187 | 203 | 6 | 3 | 3 |
| 42 years | 4,216 | 1,984 | 2,232 | 4,209 | 1,980 | 2,229 | 3,535 | 1,672 | 1,863 | 674 | 308 | 366 | 7 | 4 | 3 |
| 43 years | 3,604 | 1,722 | 1,882 | 3,593 | 1,718 | 1,875 | 3,117 | 1,492 | 1,625 | 476 | 226 | 250 | 11 | 4 | 7 |
| 44 years | 3,762 | 1,769 | 1,993 | 3,756 | 1,767 | 1,989 | 3,181 | 1,491 | 1,690 | 575 | 276 | 299 | 6 | 2 | 4 |
| 40 to 44 years | 20,464 | 9,615 | 10,849 | 20,417 | 9,595 | 10,822 | 16,759 | 7,869 | 8,890 | 3,658 | 1,726 | 1,932 | 47 | 20 | 27 |
| 45 years | 4,911 | 2,451 | 2,460 | 4,890 | 2,439 | 2,451 | 3,719 | 1,835 | 1,884 | 1,171 | 604 | 567 | 21 | 12 | 9 |
| 46 years | 3,605 | 1,766 | 1,839 | 3,603 | 1,766 | 1,837 | 3,007 | 1,524 | 1,543 | 586 | 242 | 294 | 2 | ..... | 2 |
| 47 years | 3,531 | 1,740 | 1,791 | 3,526 | 1,737 | 1,789 | 3,038 | 1,477 | 1,561 | 488 | 260 | 228 | 5 | 3 | 2 |
| 48 years | 3,678 | 1,735 | 1,943 | 3,673 | 1,733 | 1,940 | 3,012 | 1,432 | 1,580 | 661 | 301 | 360 | 5 | 2 | 3 |
| 49 years | 3,155 | 1,542 | 1,613 | 3,146 | 1,537 | 1,609 | 2,757 | 1,358 | 1,399 | 389 | 179 | 210 | 9 | 5 | 4 |
| 45 to 49 years | 18,880 | 9,234 | 9,646 | 18,838 | 9,212 | 9,626 | 15,593 | 7,626 | 7,967 | 3,245 | 1,586 | 1,659 | 42 | 22 | 20 |
| 50 years | 4,874 | 2,323 | 2,551 | 4,862 | 2,318 | 2,544 | 3,603 | 1,711 | 1,892 | 1,259 | 607 | 652 | 12 | 5 | 7 |
| 51 years | 2,733 | 1,363 | 1,370 | 2,729 | 1,360 | 1,369 | 2,442 | 1,226 | 1,216 | 287 | 134 | 153 | 4 | 3 | 1 |
| 52 years | 3,561 | 1,829 | 1,732 | 3,557 | 1,826 | 1,731 | 3,121 | 1,598 | 1,523 | 436 | 228 | 208 | 4 | 3 | 1 |
| 53 years | 3,096 | 1,491 | 1,605 | 3,092 | 1,487 | 1,605 | 2,718 | 1,324 | 1,394 | 374 | 163 | 211 | 4 | 4 | ..... |
| 54 years | 3,064 | 1,484 | 1,580 | 3,053 | 1,478 | 1,575 | 2,696 | 1,287 | 1,409 | 357 | 191 | 166 | 11 | 6 | 5 |
| 50 to 54 years | 17,328 | 8,490 | 8,838 | 17,293 | 8,469 | 8,824 | 14,580 | 7,146 | 7,434 | 2,713 | 1,323 | 1,390 | 35 | 21 | 14 |

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POPULATION OF NEW HAMPSHIRE BY SPECIFIED AGE, SEX, RACE, AND GENERAL NATIVITY, ETC., 1880.—*Concluded.*

| Ages. | ALL CLASSES. | | | WHITE. | | | | | | | | | COLORED (including Chinese, Japanese, and civilized Indians). | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Native. | | | Foreign-born. | | | | | |
| | Total. | Male. | Female. | Total. | Male. | Female. | Total. | Male. | Fem. | Total. | Male. | Fem. | Total. | Male. | Female. |
| 80 years | 928 | 410 | 518 | 926 | 409 | 517 | 840 | 371 | 469 | 86 | 38 | 48 | 2 | 1 | 1 |
| 81 years | 560 | 260 | 300 | 560 | 260 | 300 | 543 | 249 | 294 | 17 | 11 | 6 | ..... | ..... | ..... |
| 82 years | 634 | 264 | 370 | 623 | 264 | 369 | 596 | 247 | 349 | 37 | 17 | 20 | 1 | ..... | 1 |
| 83 years | 512 | 220 | 292 | 512 | 220 | 292 | 493 | 211 | 282 | 19 | 9 | 10 | ..... | ..... | ..... |
| 84 years | 483 | 186 | 297 | 482 | 186 | 296 | 454 | 178 | 276 | 28 | 8 | 20 | 1 | ..... | 1 |
| 80 to 84 years | 3,117 | 1,340 | 1,777 | 3,113 | 1,339 | 1,774 | 2,926 | 1,256 | 1,670 | 187 | 83 | 104 | 4 | 1 | 3 |
| 85 years | 359 | 151 | 208 | 358 | 150 | 208 | 350 | 147 | 203 | 8 | 3 | 5 | 1 | 1 | ..... |
| 86 years | 289 | 97 | 192 | 289 | 97 | 192 | 278 | 92 | 186 | 11 | 5 | 6 | ..... | ..... | ..... |
| 87 years | 228 | 89 | 139 | 228 | 89 | 139 | 220 | 88 | 132 | 8 | 1 | 7 | ..... | ..... | ..... |
| 88 years | 182 | 71 | 111 | 182 | 71 | 111 | 176 | 67 | 109 | 6 | 4 | 2 | ..... | ..... | ..... |
| 89 years | 142 | 67 | 75 | 142 | 67 | 75 | 137 | 64 | 73 | 5 | 3 | 2 | ..... | ..... | ..... |
| 85 to 89 years | 1,200 | 475 | 725 | 1,199 | 474 | 725 | 1,161 | 458 | 703 | 38 | 16 | 22 | 1 | 1 | ..... |
| 90 years | 109 | 37 | 72 | 109 | 37 | 72 | 97 | 29 | 68 | 12 | 8 | 4 | ..... | ..... | ..... |
| 91 years | 59 | 23 | 36 | 59 | 23 | 36 | 57 | 22 | 35 | 2 | 1 | 1 | ..... | ..... | ..... |
| 92 years | 60 | 22 | 38 | 60 | 22 | 38 | 58 | 21 | 37 | 2 | 1 | 1 | ..... | ..... | ..... |
| 93 years | 48 | 21 | 27 | 48 | 21 | 27 | 45 | 19 | 26 | 3 | 2 | 1 | ..... | ..... | ..... |
| 94 years | 28 | 9 | 19 | 28 | 9 | 19 | 26 | 9 | 17 | 2 | ..... | 2 | ..... | ..... | ..... |
| 90 to 94 years | 304 | 112 | 192 | 304 | 112 | 192 | 283 | 100 | 183 | 21 | 12 | 9 | ..... | ..... | ..... |

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# METEOROLOGICAL OBSERVATIONS:

—— INCLUDING ——

*Daily Minimum and Maximum Temperature from October, 1856, to December, 1884, inclusive; also, Average Minimum and Maximum Temperature, and Rain-Fall and Snow-Fall at Concord.*

RECORDED BY HON. WILLIAM L. FOSTER.

Copied and arranged, by order of the Secretary of the Board,

BY ROBERT H. ROLFE.

## 1856.

| DAYS. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MONTHS. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| October..... | 60 | 38 | 40 | 35 | 38 | 51 | 50 | 34 | 41 | 51 | 48 | 46 | 50 | 38 | 26 | 26 | 34 | 44 | 52 | 50 | 40 | 52 | 52 | 30 | 28 | 32 | 26 | 47 | 44 | 37 | 42 |
| November..... | 38 | 49 | 40 | 50 | 40 | 24 | 28 | 48 | 38 | 26 | 20 | 29 | 25 | 34 | 25 | 12 | 27 | 30 | 28 | 16 | 10 | 38 | 32 | 36 | 28 | 35 | 30 | 37 | 24 | 24 | |
| December..... | 6 | 16 | 26 | 28 | 15 | 23 | 21 | 7 | 15 | 2 | 4 | 38 | 36 | 30 | 26 | 0 | 8 | −19 | −16 | 10 | 26 | 0 | 18 | 16 | 10 | 10 | 12 | 16 | 16 | 24 | 20 |

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## 1857.

| Days. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Months. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| January | 25 | 21 | 22 | 23 | 12 | —5 | 0 | —6 | 8 | 1 | 21 | 0 | 0 | —5 | 12 | —5 | 14 | —24 | 10 | 8 | 18 | 16 | —32 | —37 | —20 | —22 | 23 | 22 | 20 | 21 | 13 |
| February | 26 | 15 | —4 | 14 | 31 | 24 | 40 | 44 | 24 | —3 | —9 | —14 | 34 | 36 | 34 | 44 | 14 | 47 | 33 | 22 | 25 | 18 | 24 | 30 | 48 | 32 | 10 | 20 | | | |
| March | 10 | 16 | 11 | 16 | 18 | 34 | 17 | 8 | 6 | 24 | 4 | 24 | 16 | 28 | 30 | 30 | 38 | 29 | 40 | 37 | 27 | 32 | 28 | 36 | 42 | 36 | 36 | 37 | 39 | 37 | 36 |
| April | 46 | 14 | 21 | 31 | 38 | 55 | 50 | 28 | 35 | 40 | 42 | 40 | 40 | 42 | 40 | 34 | 35 | 40 | 40 | 35 | 36 | 37 | 38 | 40 | 40 | 40 | 36 | 37 | 37 | 26 | |
| May | 49 | 37 | 58 | 50 | 48 | 52 | 50 | 48 | 55 | 40 | 40 | 40 | 50 | 52 | 43 | 38 | 42 | 40 | 44 | 50 | 43 | 48 | 55 | 60 | 60 | 60 | 52 | 58 | 62 | 58 | 56 |
| June | 56 | 70 | 60 | 58 | 54 | 52 | 52 | 52 | 55 | 62 | 56 | 64 | 63 | 60 | 56 | 59 | 59 | 53 | 53 | 60 | 70 | 64 | 63 | 59 | 67 | 57 | 61 | 64 | 57 | 61 | |
| July | 54 | 46 | 58 | 61 | 62 | 63 | 70 | 63 | 5 | 58 | 68 | 73 | 75 | 72 | 72 | 76 | 66 | 72 | 70 | 70 | 66 | 76 | 60 | 60 | 66 | 67 | 70 | 74 | 64 | 63 | 64 |
| August | 63 | 60 | 58 | 60 | 63 | 63 | 62 | 66 | 60 | 66 | 60 | 63 | 67 | 72 | 62 | 54 | 63 | 59 | 52 | 58 | 59 | 60 | 60 | 60 | 52 | 57 | 56 | 63 | 70 | 62 | 55 |
| September | 52 | 56 | 60 | 60 | 63 | 62 | 46 | 37 | 50 | 54 | 68 | 65 | 58 | 69 | 70 | 58 | 54 | 60 | 36 | 52 | 48 | 44 | 50 | 44 | 50 | 51 | 51 | 58 | 48 | 30 | |
| October | 31 | 52 | 48 | 39 | 38 | 40 | 50 | 36 | 50 | 38 | 34 | 28 | 46 | 64 | 62 | 60 | 45 | 41 | 42 | 44 | 36 | 30 | 24 | 42 | 53 | 52 | 51 | 38 | 41 | 38 | 38 |
| November | 32 | 37 | 40 | 39 | 32 | 52 | 49 | 50 | 48 | 61 | 36 | 30 | 44 | 30 | 23 | 20 | 34 | 38 | 48 | 35 | 18 | 30 | 28 | 25 | 17 | 14 | 22 | 34 | 36 | 43 | |
| December | 44 | 35 | 31 | 26 | 20 | 20 | 33 | 36 | 34 | 42 | 21 | 10 | 25 | 36 | 36 | 29 | 33 | 44 | 38 | 22 | 15 | 33 | 36 | 10 | 18 | 8 | 15 | 26 | 35 | 32 | 31 |

## 1858.

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| January | 32 | 20 | 25 | 34 | 38 | 15 | 10 | 6 | —5 | 27 | 22 | 40 | 18 | 23 | 13 | 39 | 35 | 20 | 15 | 20 | 13 | 14 | 0 | 8 | 25 | 34 | 40 | 36 | 22 | 24 | 6 |
| February | 6 | 26 | 36 | 30 | 18 | 15 | 10 | 23 | 6 | 24 | 4 | —18 | 1 | 10 | 8 | 9 | 2 | 5 | 0 | 17 | 22 | 17 | 4 | —14 | 10 | 20 | 0 | 27 | | | |
| March | 40 | 30 | 15 | —5 | 1 | 0 | 8 | 9 | 15 | 19 | 6 | 15 | 24 | 17 | 33 | 36 | 36 | 38 | 37 | 25 | 34 | 38 | 27 | 30 | 32 | 31 | 31 | 32 | 35 | 42 | 34 |
| April | 31 | 36 | 33 | 36 | 40 | 45 | 26 | 31 | 38 | 43 | 36 | 32 | 38 | 40 | 38 | 48 | 45 | 37 | 38 | 43 | 34 | 32 | 42 | 34 | 36 | 36 | 34 | 36 | 44 | 40 | |
| May | 52 | 50 | 39 | 50 | 52 | 53 | 55 | 54 | 50 | 58 | 48 | 47 | 49 | 47 | 52 | 50 | 44 | 40 | 44 | 44 | 44 | 48 | 48 | 57 | 56 | 50 | 50 | 50 | 40 | 44 | 48 |
| June | 52 | 55 | 56 | 60 | 70 | 60 | 67 | 71 | 58 | 57 | 78 | 58 | 50 | 51 | 53 | 62 | 51 | 67 | 65 | 68 | 71 | 62 | 60 | 68 | 80 | 71 | 69 | 69 | 73 | 68 | |
| July | 59 | 56 | 60 | 67 | 62 | 62 | 70 | 74 | 73 | 68 | 73 | 60 | 58 | 68 | 64 | 64 | 68 | 72 | 62 | 58 | 64 | 71 | 64 | 61 | 56 | 60 | 61 | 67 | 64 | 61 | 61 |
| August | 69 | 58 | 62 | 59 | 64 | 70 | 67 | 63 | 58 | 62 | 70 | 64 | 62 | 65 | 66 | 66 | 66 | 69 | 64 | 51 | 61 | 60 | 54 | 42 | 53 | 53 | 55 | 64 | 70 | 62 | 56 |
| September | 60 | 56 | 60 | 70 | 62 | 64 | 54 | 67 | 66 | 63 | 71 | 52 | 46 | 40 | 53 | 61 | 56 | 51 | 59 | 45 | 58 | 59 | 42 | 42 | 33 | 32 | 34 | 34 | 32 | 49 | |
| October | 59 | 44 | 44 | 68 | 54 | 36 | 32 | 40 | 41 | 44 | 35 | 44 | 45 | 48 | 41 | 30 | 44 | 48 | 40 | 40 | 48 | 48 | 51 | 52 | 36 | 22 | 30 | 38 | 32 | 46 | 54 |
| November | 36 | 40 | 38 | 39 | 41 | 42 | 35 | 37 | 30 | 34 | 25 | 17 | 16 | 20 | 13 | 16 | 26 | 33 | 34 | 20 | 33 | 22 | 32 | 32 | 29 | 30 | 25 | 26 | 15 | 14 | |
| December | 8 | 17 | 28 | 22 | 22 | 30 | 10 | 32 | 16 | 5 | 22 | 16 | 20 | 30 | 38 | 35 | 30 | 6 | —4 | 31 | 28 | 31 | 13 | 12 | 8 | —5 | 32 | 29 | 6 | 4 | 16 |

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## 1859.

| DAYS. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MONTHS. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| January | 32 | 19 | —3 | 10 | 14 | 22 | 30 | —18 | —12 | —35 | —7 | 8 | 22 | 30 | 29 | 18 | 21 | 8 | 17 | 8 | 50 | 32 | 3 | —10 | 14 | 25 | 22 | 22 | 28 | 30 | 4 |
| February | 2 | 10 | 16 | 26 | 21 | 9 | 24 | 15 | 33 | 32 | 2 | 10 | —9 | 6 | 20 | 28 | 26 | 32 | 26 | 35 | 27 | 22 | 27 | 37 | 12 | 19 | 14 | 42 | | | |
| March | 19 | 8 | 2 | 36 | 33 | 40 | 28 | 40 | 34 | 24 | 30 | 42 | 40 | 32 | 43 | 44 | 36 | 43 | 50 | 32 | 34 | 36 | 40 | 36 | 42 | 35 | 40 | 36 | 43 | 44 | 42 |
| April | 35 | 38 | 41 | 42 | 34 | 34 | 38 | 35 | 26 | 32 | 36 | 32 | 44 | 40 | 43 | 44 | 45 | 44 | 42 | 46 | 49 | 46 | 46 | 47 | 47 | 48 | 46 | 31 | 31 | 49 | |
| May | 44 | 46 | 48 | 49 | 44 | 56 | 59 | 62 | 64 | 42 | 46 | 44 | 50 | 64 | 54 | 38 | 43 | 52 | 51 | 49 | 50 | 52 | 54 | 63 | 60 | 54 | 59 | 53 | 54 | 44 | 59 |
| June | 51 | 65 | 68 | 58 | 46 | 42 | 48 | 54 | 50 | 47 | 41 | 60 | 66 | 70 | 64 | 54 | 64 | 63 | 61 | 57 | 56 | 58 | 60 | 64 | 64 | 63 | 63 | 71 | 76 | 70 | |
| July | 70 | 67 | 70 | 56 | 53 | 59 | 58 | 67 | 68 | 64 | 63 | 72 | 75 | 68 | 59 | 63 | 72 | 68 | 68 | 74 | 61 | 67 | 62 | 61 | 54 | 59 | 62 | 64 | 60 | 60 | 60 |
| August | 66 | 70 | 72 | 75 | 73 | 70 | 68 | 62 | 55 | 58 | 64 | 64 | 68 | 68 | 68 | 64 | 54 | 59 | 60 | 60 | 57 | 55 | 52 | 56 | 63 | 62 | 63 | 60 | 53 | 44 | 56 |
| September | 55 | 60 | 54 | 62 | 5 | 56 | 41 | 45 | 46 | 46 | 64 | 65 | 60 | 50 | 40 | 37 | 50 | 54 | 42 | 62 | 48 | 52 | 56 | 60 | 60 | 56 | 56 | 56 | 48 | 41 | |
| October | 48 | 60 | 46 | 44 | 48 | 56 | 36 | 44 | 40 | 30 | 32 | 30 | 38 | 32 | 32 | 20 | 37 | 52 | 38 | 32 | 27 | 30 | 39 | 28 | 43 | 20 | 26 | 31 | 26 | 19 | 32 |
| November | 27 | 38 | 36 | 32 | 33 | 37 | 18 | 32 | 30 | 38 | 48 | 30 | 38 | 30 | 28 | 20 | 38 | 34 | 56 | 44 | 23 | 28 | 34 | 28 | 24 | 36 | 35 | 34 | 23 | 20 | |
| December | 30 | 45 | 22 | 14 | 30 | 28 | 34 | 20 | 3 | 15 | 10 | 24 | 2 | 9 | 24 | —4 | —4 | 26 | 30 | 30 | 32 | 20 | 3 | 17 | —19 | 18 | 20 | —10 | 16 | 8 | —4 |

## 1860.

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| January | —2 | —3 | —4 | 13 | 3 | —8 | 18 | 37 | 34 | 34 | 37 | 21 | 12 | 10 | 30 | 30 | 24 | 12 | 19 | 27 | 20 | 32 | 16 | 42 | 24 | 15 | 18 | 8 | 32 | 34 | 37 |
| February | —3 | —8 | 0 | 14 | 21 | 36 | 38 | 28 | 18 | 17 | —3 | 7 | 10 | 28 | 4 | 18 | 12 | 0 | 23 | 8 | 14 | 22 | 44 | 36 | 25 | 18 | 32 | 39 | 35 | | |
| March | 38 | 47 | 35 | 44 | 25 | 25 | 30 | 38 | 34 | 25 | 26 | 34 | 32 | 30 | 33 | 28 | 30 | 32 | 34 | 37 | 32 | 21 | 25 | 2 | 29 | 31 | 33 | 31 | 24 | 31 | 42 |
| April | 53 | 33 | 25 | 34 | 40 | 33 | 32 | 40 | 44 | 37 | 40 | 40 | 43 | 20 | 30 | 37 | 43 | 33 | 40 | 41 | 51 | 43 | 48 | 39 | 26 | 24 | 30 | 38 | 46 | 36 | |
| May | 38 | 42 | 32 | 38 | 40 | 58 | 58 | 50 | 53 | 54 | 46 | 58 | 63 | 63 | 44 | 50 | 50 | 53 | 60 | 52 | 33 | 40 | 54 | 52 | 49 | 54 | 53 | 54 | 52 | 55 | 55 |
| June | 60 | 56 | 64 | 58 | 57 | 54 | 66 | 56 | 54 | 62 | 60 | 60 | 62 | 64 | 70 | 68 | 64 | 62 | 65 | 62 | 56 | 56 | 54 | 56 | 59 | 62 | 66 | 58 | 74 | 77 | |
| July | 66 | 62 | 62 | 70 | 60 | 47 | 60 | 58 | 65 | 72 | 64 | 59 | 63 | 54 | 47 | 67 | 64 | 50 | 64 | 75 | 66 | 62 | 59 | 59 | 54 | 54 | 66 | 59 | 56 | 60 | 56 |
| August | 56 | 56 | 51 | 62 | 66 | 53 | 58 | 76 | 72 | 68 | 72 | 66 | 66 | 66 | 53 | 56 | 64 | 64 | 60 | 64 | 64 | 70 | 66 | 70 | 66 | 66 | 62 | 60 | 52 | 60 | 66 |
| September | 54 | 51 | 44 | 50 | 63 | 60 | 53 | 70 | 46 | 41 | 48 | 58 | 41 | 45 | 56 | 62 | 48 | 52 | 53 | 64 | 62 | 55 | 57 | 54 | 66 | 56 | 45 | 36 | 32 | 30 | |
| October | 28 | 48 | 44 | 46 | 52 | 40 | 35 | 50 | 46 | 46 | 56 | 46 | 26 | 30 | 39 | 32 | 32 | 38 | 36 | 50 | 45 | 50 | 52 | 44 | 38 | 46 | 40 | 34 | 45 | 50 | 59 |
| November | 56 | 56 | 51 | 60 | 32 | 47 | 40 | 32 | 32 | 40 | 45 | 4 | 42 | 38 | 30 | 38 | 28 | 42 | 40 | 34 | 31 | 20 | 24 | 50 | 16 | 15 | 33 | 35 | 18 | 25 | |
| December | 26 | 26 | 26 | 28 | 28 | 24 | 8 | 20 | 16 | 17 | 15 | 8 | 22 | 2 | —5 | 0 | 5 | 14 | 0 | 27 | 38 | 31 | 16 | 12 | 22 | 28 | 14 | 22 | 24 | 26 | 32 |

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# 1861.

| Days. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Months. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| January | 13 | 20 | 20 | 24 | 2 | 10 | 23 | 22 | 2 | 10 | —3 | 0 | —12 | —14 | 24 | 28 | 20 | 18 | 14 | 27 | 12 | 15 | 6 | 4 | 30 | 20 | 22 | 0 | —6 | 25 | 28 |
| February | 10 | 32 | 36 | 12 | 18 | 32 | 32 | —26 | —18 | 18 | 27 | 44 | 35 | 22 | 28 | 26 | 39 | 35 | 28 | 30 | 25 | 11 | 18 | 34 | 5 | 30 | 20 | 28 | | | |
| March | 36 | 35 | 38 | 40 | 26 | 19 | —2 | 0 | 36 | 36 | 20 | 30 | 24 | 16 | 30 | 28 | 32 | —4 | 12 | 9 | 20 | 28 | 25 | 36 | 23 | 40 | 40 | 36 | 33 | 43 | 28 |
| April | 20 | 32 | 26 | 12 | 29 | 39 | 28 | 24 | 30 | 33 | 36 | 36 | 48 | 50 | 42 | 39 | 34 | 32 | 36 | 36 | 40 | 40 | 45 | 45 | 43 | 46 | 46 | 46 | 46 | 46 | |
| May | 49 | 32 | 26 | 28 | 28 | 36 | 58 | 46 | 44 | 54 | 46 | 54 | 53 | 49 | 52 | 44 | 50 | 54 | 50 | 56 | 56 | 50 | 46 | 42 | 52 | 55 | 57 | 44 | 41 | 40 | 45 |
| June | 49 | 56 | 50 | 57 | 41 | 50 | 56 | 57 | 54 | 58 | 68 | 56 | 44 | 58 | 58 | 68 | 55 | 44 | 48 | 62 | 48 | 60 | 52 | 53 | 56 | 66 | 70 | 65 | 51 | 62 | |
| July | 62 | 60 | 60 | 52 | 59 | 68 | 70 | 66 | 77 | 77 | 70 | 66 | 50 | 60 | 60 | 57 | 64 | 54 | 68 | 68 | 64 | 63 | 62 | 62 | 58 | 58 | 59 | 63 | 70 | 70 | 67 |
| August | 72 | 70 | 76 | 74 | 78 | 70 | 61 | 62 | 58 | 55 | 64 | 56 | 57 | 55 | 48 | 46 | 56 | 54 | 67 | 59 | 57 | 64 | 60 | 52 | 59 | 56 | 60 | 54 | 63 | 56 | 54 |
| September | 48 | 44 | 63 | 66 | 50 | 57 | 64 | 58 | 47 | 42 | 50 | 58 | 52 | 67 | 54 | 52 | 52 | 58 | 52 | 62 | 58 | 54 | 50 | 44 | 40 | 43 | 50 | 72 | 50 | 46 | |
| October | 49 | 49 | 49 | 59 | 48 | 52 | 72 | 56 | 40 | 42 | 52 | 57 | 44 | 44 | 40 | 37 | 52 | 62 | 60 | 50 | 37 | 37 | 50 | 40 | 30 | 36 | 46 | 30 | 37 | 32 | 32 |
| November | 40 | 40 | 48 | 44 | 30 | 44 | 40 | 37 | 36 | 33 | 28 | 37 | 32 | 34 | 30 | 30 | 36 | 30 | 20 | 20 | 26 | 18 | 24 | 38 | 29 | 36 | 29 | 34 | 30 | 34 | |
| December | 24 | 28 | 8 | 10 | 15 | 33 | 37 | 44 | 38 | 40 | 52 | 20 | 20 | 25 | 28 | 30 | 22 | 35 | 22 | 42 | 2 | 12 | 25 | 23 | 4 | —12 | 32 | 7 | 4 | 22 | 16 |

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| January | 16 | 10 | 0 | 0 | —2 | —2 | 12 | 0 | 32 | 28 | 17 | 17 | 24 | 2 | 7 | 29 | 1 | 16 | 25 | 27 | 20 | 20 | 20 | 3 | 22 | 30 | 14 | 2 | 18 | 24 | 12 |
| February | —8 | 8 | —5 | 14 | 8 | 1 | 37 | 10 | 0 | —10 | 20 | 6 | 28 | 9 | —7 | —10 | 22 | 22 | 28 | 11 | 11 | 22 | 34 | 2 | 11 | 24 | 0 | 20 | | | |
| March | 12 | 16 | 5 | 34 | 28 | 18 | 28 | 36 | 22 | 36 | 37 | 22 | 20 | 27 | 27 | 28 | 30 | 26 | 13 | 18 | 31 | 32 | 27 | 37 | 34 | 26 | 26 | 23 | 24 | 18 | 33 |
| April | 23 | 30 | 32 | 36 | 28 | 26 | 28 | 20 | 22 | 36 | 34 | 30 | 26 | 29 | 40 | 37 | 43 | 52 | 58 | 41 | 30 | 40 | 45 | 30 | 24 | 26 | 31 | 36 | 40 | 41 | |
| May | 41 | 42 | 48 | 45 | 40 | 40 | 39 | 40 | 37 | 57 | 45 | 40 | 44 | 37 | 37 | 44 | 57 | 57 | 63 | 47 | 52 | 58 | 45 | 44 | 50 | 33 | 42 | 50 | 46 | 44 | 39 |
| June | 48 | 56 | 62 | 60 | 61 | 54 | 49 | 50 | 49 | 38 | 44 | 53 | 54 | 65 | 42 | 42 | 40 | 57 | 59 | 47 | 48 | 50 | 42 | 57 | 53 | 53 | 54 | 58 | 62 | 58 | |
| July | 52 | 44 | 54 | 50 | 62 | 65 | 67 | 70 | 59 | 58 | 46 | 51 | 58 | 65 | 68 | 63 | 61 | 52 | 48 | 57 | 58 | 51 | 55 | 55 | 61 | 57 | 60 | 52 | 64 | 61 | 58 |
| August | 58 | 62 | 61 | 61 | 71 | 68 | 54 | 63 | 71 | 70 | 54 | 69 | 54 | 43 | 62 | 47 | 45 | 46 | 47 | 56 | 62 | 64 | 69 | 49 | 37 | 60 | 61 | 62 | 62 | 43 | 42 |
| September | 62 | 57 | 40 | 39 | 49 | 57 | 61 | 63 | 62 | 40 | 46 | 58 | 58 | 53 | 53 | 55 | 42 | 56 | 60 | 58 | 58 | 38 | 45 | 56 | 36 | 37 | 38 | 46 | 61 | 51 | |
| October | 44 | 47 | 52 | 62 | 50 | 39 | 56 | 58 | 63 | 56 | 52 | 35 | 45 | 48 | 38 | 38 | 49 | 37 | 42 | 42 | 25 | 50 | 40 | 26 | 54 | 37 | 44 | 34 | 28 | 30 | 34 |
| November | 45 | 48 | 57 | 30 | 34 | 32 | 31 | 30 | 37 | 26 | 30 | 46 | 42 | 30 | 32 | 14 | 30 | 32 | 38 | 46 | 50 | 44 | 27 | 16 | 24 | 32 | 30 | 29 | 32 | 30 | |
| December | 34 | 32 | 17 | 8 | 32 | 32 | 6 | 6 | —4 | 16 | 12 | 40 | 32 | 28 | 34 | 55 | 32 | 8 | 15 | —7 | —5 | 8 | 26 | 13 | 23 | 33 | 37 | 28 | 26 | 30 | 22 |

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## 1863.

| DAYS. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MONTHS. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| January | 12 | 12 | 18 | 12 | 30 | 29 | 28 | 5 | 10 | 22 | 35 | 20 | 14 | 29 | 40 | 37 | 14 | 2 | 2 | 13 | 30 | 25 | 33 | 22 | 28 | 26 | 34 | 30 | 26 | 20 | 20 |
| February | 20 | 41 | 7 | —20 | —20 | 30 | 28 | 18 | 34 | 34 | 18 | 23 | 18 | —9 | 30 | 27 | 12 | 4 | 34 | 10 | 0 | 12 | 12 | 12 | 16 | 35 | 30 | 28 | | | |
| March | 28 | 28 | 23 | 14 | 0 | 16 | 28 | 18 | 20 | 10 | 30 | 11 | —11 | —14 | —2 | —9 | —4 | 26 | 4 | —2 | —6 | 30 | 26 | 26 | 36 | 43 | 36 | 20 | 34 | 28 | 20 |
| April | 30 | 19 | 30 | 20 | 34 | 38 | 32 | 25 | 29 | 38 | 42 | 40 | 38 | 31 | 38 | 38 | 44 | 43 | 47 | 47 | 30 | 30 | 42 | 45 | 35 | 42 | 50 | 44 | 30 | 34 | |
| May | 38 | 44 | 48 | 47 | 48 | 45 | 4[illegible] | 47 | 67 | 55 | 47 | 50 | 38 | 36 | 52 | 47 | 48 | 48 | 52 | 58 | 60 | 52 | 40 | 40 | 45 | 45 | 52 | 56 | 35 | 40 | 68 |
| June | 61 | 50 | 50 | 43 | 43 | 59 | 52 | 51 | 52 | 47 | 56 | 62 | 54 | 45 | 69 | 50 | 54 | 44 | 55 | 44 | 51 | 51 | 53 | 48 | 42 | 53 | 53 | 58 | 54 | 55 | |
| July | 59 | 62 | 66 | 64 | 64 | 62 | 62 | 69 | 70 | 66 | 62 | 66 | 66 | 59 | 63 | 68 | 63 | 64 | 69 | 66 | 55 | 53 | 56 | 61 | 69 | 67 | 61 | 64 | 72 | 75 | 75 |
| August | 70 | 66 | 76 | 57 | 60 | 66 | 65 | 61 | 68 | 70 | 65 | 70 | 54 | 55 | 68 | 52 | 56 | 41 | 53 | 65 | 63 | 66 | 64 | 68 | 73 | 57 | 50 | 46 | 57 | 53 | 41 |
| September | 45 | 54 | 57 | 55 | 50 | 52 | 58 | 63 | 62 | 42 | 42 | 56 | 56 | 53 | 57 | 63 | 60 | 69 | 56 | 46 | 44 | 46 | 28 | 36 | 47 | 42 | 45 | 32 | 34 | 42 | |
| October | 40 | 45 | 56 | 56 | 52 | 40 | 38 | 50 | 48 | 36 | 45 | 41 | 33 | 29 | 44 | 50 | 54 | 51 | 59 | 38 | 45 | 40 | 34 | 47 | 34 | 31 | 24 | 24 | 19 | 30 | 51 |
| November | 40 | 27 | 45 | 42 | 35 | 50 | 35 | 32 | 24 | 32 | 24 | 30 | 34 | 32 | 43 | 48 | 56 | 51 | 36 | 40 | 32 | 40 | 32 | 22 | 32 | 26 | 24 | 28 | 43 | 20 | |
| December | 18 | 30 | 10 | 36 | 39 | 10 | 3 | 6 | 25 | 0 | —3 | 20 | 32 | 31 | 34 | 20 | 17 | 22 | 20 | 12 | 8 | —5 | —3 | 14 | 6 | 8 | 18 | 19 | 26 | 30 | 23 |

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| January | 37 | 1 | 1 | 6 | 6 | 7 | —5 | 2 | 2 | 6 | 18 | 19 | 19 | 8 | 18 | 22 | 2 | 23 | 38 | 32 | 12 | 10 | 32 | 40 | 42 | 38 | 27 | 27 | 27 | 36 | 25 |
| February | 24 | 29 | 32 | 22 | 32 | 22 | 35 | 30 | 30 | 25 | 7 | —2 | 32 | 32 | 36 | 8 | 14 | 0 | —10 | —16 | 3 | 20 | 28 | 36 | 39 | 37 | 33 | 23 | 37 | | |
| March | 25 | 27 | 20 | 12 | 34 | 40 | 35 | 31 | 31 | 24 | 34 | 40 | 40 | 24 | 23 | 20 | 18 | 30 | 30 | 20 | 13 | 9 | 20 | 27 | 36 | 32 | 36 | 37 | 28 | 30 | 36 |
| April | 35 | 34 | 34 | 31 | 32 | 32 | 31 | 35 | 36 | 32 | 34 | 32 | 32 | 31 | 31 | 33 | 42 | 36 | 35 | 37 | 39 | 36 | 44 | 49 | 43 | 45 | 47 | 42 | 40 | 42 | |
| May | 45 | 45 | 42 | 41 | 36 | 56 | 60 | 47 | 52 | 52 | 56 | 48 | 48 | 52 | 58 | 60 | 52 | 62 | 49 | 49 | 56 | 51 | 41 | 49 | 47 | 50 | 60 | 54 | 49 | 52 | 52 |
| June | 64 | 55 | 52 | 47 | 47 | 70 | 54 | 44 | 58 | 45 | 39 | 41 | 42 | 52 | 54 | 48 | 62 | 51 | 57 | 62 | 59 | 60 | 68 | 55 | 70 | 78 | 75 | 45 | 42 | 48 | |
| July | 60 | 62 | 58 | 60 | 60 | 58 | 63 | 55 | 49 | 56 | 68 | 66 | 63 | 57 | 58 | 55 | 59 | 60 | 62 | 68 | 72 | 48 | 48 | 56 | 57 | 63 | 70 | 58 | 68 | 57 | 62 |
| August | 64 | 75 | 62 | 60 | 64 | 64 | 64 | 52 | 62 | 68 | 76 | 53 | 79 | 73 | 57 | 60 | 65 | 61 | 60 | 57 | 60 | 63 | 69 | 65 | 60 | 63 | 64 | 60 | 58 | 58 | 52 |
| September | 50 | 50 | 54 | 53 | 50 | 45 | 47 | 50 | 40 | 48 | 52 | 50 | 48 | 50 | 54 | 50 | 42 | 42 | 60 | 40 | 50 | 50 | 51 | 62 | 54 | 40 | 38 | 59 | 57 | 62 | |
| October | 38 | 47 | 48 | 51 | 44 | 47 | 63 | 48 | 36 | 28 | 36 | 30 | 45 | 42 | 38 | 35 | 40 | 42 | 38 | 34 | 45 | 26 | 30 | 32 | 37 | 40 | 28 | 50 | 40 | 26 | 32 |
| November | 33 | 32 | 22 | 34 | 39 | 20 | 35 | 33 | 47 | 65 | 37 | 30 | 36 | 18 | 20 | 10 | 40 | 35 | 24 | 37 | 42 | 32 | 23 | 31 | 23 | 40 | 32 | 30 | 44 | 45 | |
| December | 42 | 32 | 34 | 40 | 30 | 33 | 34 | 34 | 16 | 17 | 27 | 16 | 0 | 19 | 6 | 15 | 27 | 30 | 18 | 16 | 0 | 14 | —13 | 0 | 14 | 34 | 36 | 37 | 37 | 25 | 28 |

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| Days. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Months. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| January | 12 | 5 | —2 | 19 | 10 | 24 | 30 | 0 | 11 | 30 | 18 | 16 | 18 | 27 | 8 | 3 | —4 | 4 | —13 | 13 | 15 | 15 | 26 | 25 | 10 | —3 | —15 | —18 | —15 | 17 | 3 |
| February | 30 | 11 | —4 | 25 | 32 | 22 | 28 | 34 | 20 | 3 | 14 | 0 | 2 | 5 | 1 | 25 | 32 | 15 | 27 | 25 | 10 | 4 | 35 | 26 | 2 | 34 | 37 | 17 | | | |
| March | 23 | 26 | 30 | 35 | 25 | 12 | 10 | 36 | 31 | 34 | 19 | 14 | 18 | 28 | 30 | 42 | 42 | 32 | 34 | 37 | 38 | 35 | 32 | 32 | 34 | 32 | 38 | 30 | 41 | 42 | 42 |
| April | 37 | 41 | 34 | 27 | 39 | 52 | 58 | 40 | 30 | 35 | 39 | 40 | 48 | 40 | 42 | 48 | 32 | 37 | 47 | 40 | 34 | 36 | 42 | 33 | 30 | 38 | 50 | 54 | 50 | 48 | |
| May | 42 | 42 | 46 | 46 | 40 | 42 | 43 | 37 | 54 | 43 | 45 | 43 | 56 | 65 | 47 | 52 | 45 | 49 | 60 | 63 | 60 | 50 | 56 | 54 | 44 | 52 | 52 | 54 | 49 | 38 | 43 |
| June | 63 | 58 | 45 | 66 | 62 | 56 | 50 | 70 | 66 | 64 | 64 | 58 | 69 | 50 | 48 | 54 | 62 | 70 | 62 | 61 | 70 | 60 | 58 | 58 | 62 | 66 | 70 | 56 | 57 | 76 | |
| July | 70 | 62 | 60 | 60 | 57 | 58 | 60 | 63 | 54 | 51 | 58 | 57 | 64 | 52 | 48 | 60 | 64 | 52 | 60 | 66 | 60 | 60 | 53 | 58 | 58 | 70 | 64 | 59 | 70 | 54 | 52 |
| August | 53 | 56 | 65 | 69 | 72 | 65 | 68 | 56 | 55 | 58 | 63 | 55 | 50 | 57 | 63 | 60 | 55 | 53 | 56 | 66 | 63 | 49 | 47 | 44 | 55 | 49 | 65 | 47 | 42 | 45 | 57 |
| September | 66 | 62 | 50 | 56 | 61 | 74 | 52 | 58 | 50 | 50 | 64 | 73 | 50 | 60 | 70 | 54 | 50 | 47 | 44 | 41 | 53 | 62 | 56 | 57 | 64 | 52 | 36 | 39 | 40 | 42 | |
| October | 58 | 42 | 40 | 38 | 39 | 38 | 32 | 52 | 45 | 55 | 40 | 43 | 33 | 30 | 45 | 37 | 40 | 33 | 53 | 48 | 40 | 33 | 44 | 30 | 26 | 33 | 31 | 32 | 34 | 32 | 30 |
| November | 36 | 29 | 46 | 38 | 44 | 27 | 38 | 25 | 30 | 31 | 24 | 21 | 32 | 41 | 33 | 45 | 40 | 49 | 38 | 35 | 37 | 45 | 37 | 48 | 42 | 38 | 27 | 31 | 21 | 39 | |
| December | 38 | 33 | 36 | 40 | 42 | 32 | 31 | 12 | 6 | 25 | 18 | 26 | 40 | 32 | 14 | 8 | 16 | 10 | 30 | 30 | 18 | —3 | 5 | 17 | 18 | 26 | 38 | 30 | 24 | 20 | 20 |

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| January | 35 | 28 | 25 | 16 | —10 | —3 | —4 | —16 | 3 | 15 | 28 | 30 | 29 | 16 | —6 | 8 | 25 | 31 | 22 | 32 | 12 | 10 | 20 | 7 | 18 | 22 | 14 | —2 | 15 | —6 | 25 |
| February | 10 | 12 | —5 | 10 | —2 | 3 | —2 | 16 | 26 | 20 | 29 | 39 | 35 | 32 | 35 | 0 | 3 | 17 | 34 | 32 | 18 | 30 | 36 | 46 | 34 | 6 | 14 | 20 | | | |
| March | 27 | 30 | 34 | 36 | 18 | 16 | 22 | 10 | 18 | 13 | 10 | 38 | 43 | 32 | 8 | 20 | 18 | 28 | 26 | 22 | 30 | 32 | 16 | 26 | 26 | 40 | 41 | 38 | 26 | 36 | 28 |
| April | 44 | 41 | 40 | 37 | 38 | 58 | 40 | 35 | 35 | 30 | 45 | 38 | 45 | 42 | 42 | 42 | 42 | 32 | 50 | 60 | 50 | 53 | 60 | 55 | 50 | 45 | 40 | 40 | 33 | 44 | 32 |
| May | 38 | 45 | 43 | 46 | 46 | 52 | 42 | 34 | 50 | 54 | 42 | 50 | 53 | 45 | 42 | 52 | 38 | 48 | 52 | 41 | 40 | 44 | 39 | 34 | 43 | 34 | 45 | 47 | 48 | 50 | 51 |
| June | 38 | 45 | 52 | 50 | 52 | 54 | 52 | 51 | 49 | 46 | 47 | 47 | 52 | 50 | 55 | 49 | 50 | 61 | 58 | 54 | 54 | 64 | 61 | 58 | 58 | 73 | 69 | 65 | 56 | 52 | |
| July | 47 | 48 | 58 | 58 | 67 | 71 | 71 | 74 | 70 | 51 | 55 | 55 | 72 | 69 | 57 | 74 | 68 | 78 | 61 | 54 | 56 | 56 | 58 | 53 | 56 | 56 | 63 | 63 | 57 | 55 | 55 |
| August | 52 | 67 | 60 | 52 | 56 | 51 | 60 | 56 | 56 | 54 | 48 | 49 | 51 | 56 | 60 | 50 | 45 | 58 | 65 | 43 | 57 | 49 | 44 | 41 | 40 | 44 | 50 | 52 | 55 | 50 | |
| September | 48 | 65 | 61 | 60 | 61 | 58 | 48 | 60 | 52 | 42 | 39 | 61 | 5 | 56 | 47 | 32 | 42 | 60 | 55 | 52 | 50 | 47 | 29 | 33 | 54 | 62 | 46 | 38 | 40 | 45 | |
| October | 42 | 36 | 50 | 25 | 28 | 23 | 27 | 42 | 49 | 32 | 30 | 31 | 41 | 42 | 44 | 31 | 36 | 27 | 31 | 38 | 41 | 49 | 52 | 28 | 30 | 21 | 33 | 29 | 30 | 54 | 39 |
| November | 25 | 32 | 27 | 20 | 15 | 26 | 19 | 40 | 26 | 27 | 33 | 38 | 30 | 20 | 27 | 45 | 27 | 28 | 30 | 50 | 35 | 30 | 32 | 27 | 22 | 16 | 19 | 32 | 63 | 58 | |
| December | 32 | 20 | 18 | 26 | 42 | 27 | 32 | 23 | 33 | 21 | 11 | 8 | 6 | 8 | 7 | 2 | 16 | 17 | 11 | 3 | —17 | —11 | 19 | 46 | 25 | 19 | 15 | 22 | 0 | —4 | —5 |

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## 1867.

| DAYS. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
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| MONTHS. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| January | 15 | 8 | —7 | —9 | 10 | 21 | 16 | 7 | 8 | —2 | —6 | 1 | 0 | 8 | —9 | —3 | 7 | 3 | —4 | —17 | 4 | 17 | 19 | 21 | 1 | 14 | 19 | 8 | —4 | —6 | —20 |
| February | 38 | 16 | 26 | 30 | 28 | 20 | 15 | 13 | 33 | 26 | —2 | 19 | 27 | 40 | 24 | 15 | 26 | 20 | 22 | 9 | 5 | 17 | 5 | 19 | 11 | 7 | 21 | 10 | | | |
| March | 16 | 22 | 4 | 15 | 18 | 10 | 17 | 19 | 10 | 26 | 27 | 28 | 27 | 28 | 6 | 3 | 15 | 19 | 14 | 15 | 18 | 24 | 18 | 26 | 29 | 17 | 23 | 25 | 21 | 26 | 30 |
| April | 27 | 30 | 30 | 26 | 34 | 27 | 26 | 28 | 32 | 24 | 36 | 24 | 32 | 17 | 34 | 56 | 44 | 34 | 30 | 30 | 43 | 32 | 38 | 32 | 33 | 25 | 33 | 26 | 22 | 37 | |
| May | 54 | 40 | 26 | 24 | 30 | 40 | 44 | 48 | 43 | 39 | 38 | 37 | 35 | 44 | 43 | 38 | 41 | 42 | 38 | 43 | 39 | 41 | 39 | 38 | 39 | 53 | 48 | 53 | 55 | 49 | 54 |
| June | 42 | 51 | 60 | 58 | 50 | 49 | 67 | 57 | 46 | 43 | 48 | 60 | 54 | 53 | 48 | 60 | 64 | 60 | 60 | 50 | 60 | 60 | 56 | 64 | 60 | 45 | 57 | 61 | 56 | 59 | |
| July | 71 | 51 | 55 | 64 | 62 | 59 | 61 | 59 | 58 | 58 | 54 | 68 | 58 | 49 | 50 | 53 | 53 | 50 | 57 | 57 | 54 | 57 | 56 | 57 | 69 | 69 | 57 | 67 | 74 | 56 | 47 |
| August | 53 | 60 | 62 | 56 | 56 | 61 | 67 | 69 | 69 | 67 | 61 | 49 | 59 | 66 | 70 | 67 | 66 | 65 | 68 | 60 | 57 | 56 | 61 | 56 | 60 | 52 | 55 | 59 | 68 | 55 | 41 |
| September | 47 | 53 | 61 | 59 | 49 | 64 | 62 | 47 | 52 | 61 | 42 | 40 | 48 | 45 | 32 | 39 | 57 | 58 | 65 | 51 | 55 | 42 | 40 | 29 | 46 | 49 | 37 | 33 | 40 | 36 | |
| October | 34 | 36 | 49 | 27 | 37 | 48 | 35 | 30 | 36 | 45 | 43 | 42 | 37 | 28 | 27 | 36 | 37 | 55 | 41 | 40 | 48 | 50 | 36 | 20 | 22 | 28 | 25 | 26 | 34 | 44 | 45 |
| November | 34 | 33 | 33 | 59 | 22 | 26 | 11 | 25 | 33 | 40 | 39 | 32 | 25 | 18 | 20 | 16 | 19 | 10 | 9 | 3 | 21 | 9 | 26 | 30 | 34 | 37 | 30 | 26 | 31 | 31 | |
| December | 1 | 13 | 9 | 8 | 1 | 8 | 32 | 6 | —11 | —10 | —16 | —8 | —4 | —10 | 6 | 15 | 12 | 13 | —4 | —8 | 8 | 20 | 28 | 8 | 19 | 27 | 24 | 37 | 12 | 10 | —4 |

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| January | Min. | 22 | 24 | 27 | 23 | —5 | 8 | 9 | 23 | 20 | 2 | —7 | —3 | —1 | 5 | 5 | —3 | —6 | 0 | —6 | 5 | 20 | 12 | —1 | 20 | 15 | 11 | 7 | 3 | 12 | 17 | —5 |
| February | Min. | 2 | —10 | —6 | —19 | —15 | 14 | 10 | —9 | —6 | 2 | —10 | —18 | 10 | 5 | 8 | 9 | —5 | 15 | 8 | 15 | 31 | —1 | —10 | —11 | —3 | —9 | 4 | 20 | 8 | | |
| March | Min. | —5 | 0 | 1 | 1 | —3 | —8 | 31 | 34 | 27 | 28 | 30 | 8 | 31 | 34 | 32 | 31 | 33 | 36 | 23 | 21 | 24 | 24 | 19 | 17 | 16 | 15 | 17 | 21 | 19 | 24 | 16 |
| April | Min. | 22 | 37 | 26 | 17 | 19 | 13 | 23 | 26 | 17 | 10 | 17 | 34 | 14 | 13 | 34 | 55 | 53 | 40 | 33 | 42 | 40 | 34 | 37 | 20 | 39 | 29 | 25 | 21 | 26 | 36 | |
| May | Min. | 40 | 34 | 39 | 28 | 37 | 40 | 32 | 35 | 36 | 40 | 31 | 32 | 48 | 50 | 53 | 37 | 53 | 54 | 45 | 44 | 47 | 46 | 46 | 47 | 49 | 53 | 58 | 52 | 58 | 50 | 55 |
| June | Min. | 47 | 44 | 40 | 40 | 40 | 58 | 65 | 53 | 56 | 41 | 47 | 46 | 51 | 59 | 57 | 64 | 63 | 64 | 67 | 68 | 70 | 59 | 54 | 50 | 47 | 54 | 56 | 55 | 52 | 55 | |
| July | Min. | 54 | 63 | 73 | 69 | 74 | 65 | 52 | 65 | 64 | 56 | 64 | 69 | 71 | 78 | 80 | 76 | 62 | 60 | 68 | 71 | 64 | 64 | 60 | 60 | 63 | 59 | 51 | 60 | 60 | 61 | 62 |
| August | Min. | 69 | 68 | 68 | 68 | 65 | 60 | 60 | 60 | 68 | 58 | 57 | 59 | 45 | 48 | 52 | 61 | 45 | 47 | 66 | 70 | 63 | 57 | 52 | 51 | 57 | 56 | 63 | 46 | 52 | 66 | 58 |
| September | Min. | 63 | 54 | 54 | 54 | 57 | 50 | 58 | 51 | 50 | 61 | 60 | 66 | 61 | 57 | 45 | 48 | 34 | 29 | 30 | 46 | 42 | 30 | 42 | 46 | 42 | 48 | 45 | 40 | 40 | 35 | |
| | Max. | 81 | 76 | 72 | 61 | 73 | 71 | 68 | 74 | 64 | 66 | 71 | 74 | 72 | 62 | 71 | 68 | 62 | 68 | 69 | 68 | 66 | 61 | 52 | 52 | 52 | 63 | 51 | 71 | 54 | 65 | |
| October | Min. | 40 | 41 | 44 | 30 | 38 | 37 | 47 | 30 | 54 | 33 | 26 | 32 | 40 | 27 | 44 | 39 | 27 | 18 | 27 | 39 | 31 | 30 | 28 | 18 | 20 | 37 | 23 | 46 | 27 | 29 | 15 |
| | Max. | 65 | 51 | 66 | 63 | 70 | 62 | 65 | 76 | 63 | 64 | 68 | 61 | 71 | 52 | 55 | 67 | 39 | 52 | 48 | 57 | 41 | 42 | 47 | 49 | 55 | 58 | 58 | 65 | 43 | 54 | 44 |
| November | Min. | 53 | 30 | 27 | 24 | 27 | 36 | 22 | 19 | 30 | 33 | 30 | 26 | 18 | 17 | 19 | 15 | 12 | 20 | 28 | 22 | 26 | 27 | 22 | 19 | 22 | 29 | 27 | 18 | 26 | 24 | |
| | Max. | 61 | 34 | 34 | 53 | 40 | 43 | 40 | 30 | 36 | 33 | 39 | 39 | 52 | 51 | 35 | 45 | 36 | 28 | 39 | 42 | 38 | 41 | 40 | 41 | 42 | 41 | 33 | 44 | 34 | 32 | |
| December | Min. | 19 | 11 | 16 | 21 | 13 | 23 | 19 | 20 | 15 | 5 | 18 | 14 | 13 | 5 | 16 | 3 | 16 | 33 | 1 | 8 | 25 | 28 | 23 | 4 | —4 | 5 | —10 | 13 | 5 | 17 | —5 |
| | Max. | 26 | 24 | 32 | 22 | 28 | 24 | 30 | 25 | 25 | 32 | 32 | 28 | 34 | 26 | 18 | 30 | 37 | 33 | 14 | 28 | 35 | 37 | 23 | 20 | 23 | 24 | 14 | 36 | 37 | 30 | 38 |

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| DAYS. | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
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| MONTHS. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| January | Min. | 9 | 5 | 16 | 10 | 32 | 26 | 11 | 36 | 30 | 36 | 14 | 24 | 16 | 14 | 13 | 17 | 5 | 7 | 8 | 5 | 5 | —1 | —15 | 19 | 19 | 2 | 1 | 20 | 17 | 30 | 31 |
| | Max. | 9 | 25 | 30 | 28 | 42 | 34 | 53 | 58 | 40 | 47 | 32 | 38 | 44 | 47 | 34 | 37 | 37 | 35 | 37 | 35 | 29 | 18 | 29 | 41 | 25 | 28 | 38 | 42 | 52 | 34 | 31 |
| February | Min. | 16 | 1 | 14 | 14 | 12 | 14 | 16 | —6 | 21 | 26 | 28 | 21 | 33 | 27 | 16 | 32 | 22 | 28 | 10 | 6 | 19 | 3 | 23 | 10 | 9 | 16 | 26 | 12 | | | |
| | Max. | 29 | 35 | 26 | 33 | 26 | 36 | 26 | 44 | 51 | 38 | 36 | 48 | 59 | 29 | 32 | 44 | 42 | 43 | 40 | 31 | 49 | 39 | 26 | 32 | 38 | 30 | 35 | 35 | | | |
| March | Min. | 14 | —18 | 10 | 9 | —4 | —20 | 10 | 0 | 20 | 27 | 16 | 17 | 13 | 22 | 0 | 10 | 5 | —5 | 0 | 26 | 9 | 2 | 18 | 18 | 8 | 10 | 32 | 30 | 26 | 32 | 38 |
| | Max. | 34 | 34 | 48 | 43 | 21 | 22 | 26 | 38 | 45 | 38 | 40 | 48 | 45 | 47 | 36 | 37 | 42 | 42 | 42 | 49 | 18 | 40 | 40 | 46 | 42 | 40 | 62 | 70 | 36 | 36 | 45 |
| April | Min. | 28 | 30 | 32 | 22 | 20 | 30 | 24 | 25 | 23 | 29 | 28 | 24 | 28 | 20 | 24 | 22 | 26 | 36 | 44 | 40 | 46 | 40 | 33 | 41 | 43 | 37 | 33 | 44 | 43 | 26 | |
| | Max. | 44 | 51 | 46 | 36 | 43 | 50 | 54 | 50 | 49 | 47 | 56 | 56 | 55 | 56 | 58 | 68 | 68 | 69 | 61 | 56 | 64 | 55 | 72 | 66 | 62 | 78 | 78 | 74 | 65 | 64 | |
| May | Min. | 25 | 32 | 32 | 35 | 36 | 31 | 34 | 36 | 38 | 62 | 46 | 50 | 52 | 53 | 31 | 38 | 47 | 47 | 48 | 45 | 46 | 45 | 35 | 42 | 44 | 53 | 42 | 44 | 48 | 48 | 58 |
| | Max. | 53 | 37 | 50 | 47 | 61 | 69 | 76 | 76 | 85 | 93 | 77 | 62 | 70 | 68 | 73 | 76 | 64 | 67 | 62 | 69 | 64 | 69 | 73 | 77 | 86 | 83 | 66 | 73 | 63 | 76 | 78 |
| June | Min. | 57 | 55 | 58 | 56 | 67 | 54 | 40 | 40 | 40 | 41 | 52 | 46 | 43 | 68 | 61 | 50 | 50 | 50 | 55 | 49 | 60 | 56 | 55 | 54 | 60 | 50 | 59 | 60 | 60 | 62 | |
| | Max. | 83 | 78 | 85 | 88 | 81 | 67 | 66 | 63 | 70 | 73 | 71 | 64 | 74 | 78 | 75 | 69 | 74 | 67 | 73 | 61 | 76 | 62 | 71 | 79 | 78 | 70 | 67 | 66 | 83 | 76 | |
| July | Min. | 50 | 46 | 50 | 67 | 56 | 45 | 49 | 58 | 64 | 58 | 66 | 60 | 54 | 59 | 63 | 65 | 70 | 62 | 56 | 51 | 62 | 57 | 53 | 60 | 62 | 67 | 69 | 62 | 66 | 59 | 51 |
| | Max. | 66 | 76 | 82 | 85 | 74 | 77 | 81 | 86 | 74 | 78 | 91 | 77 | 78 | 79 | 70 | 90 | 80 | 84 | 84 | 83 | 70 | 74 | 83 | 80 | 89 | 81 | 83 | 87 | 82 | 77 | 78 |
| August | Min. | 53 | 56 | 59 | 57 | 58 | 48 | 42 | 41 | 46 | 51 | 59 | 58 | 48 | 58 | 48 | 58 | 58 | 58 | 58 | 67 | 74 | 64 | 52 | 52 | 63 | 64 | 55 | 53 | 68 | 58 | 52 |
| | Max. | 81 | 83 | 85 | 76 | 70 | 71 | 69 | 76 | 84 | 88 | 88 | 81 | 80 | 76 | 63 | 63 | 67 | 74 | 82 | 89 | 78 | 80 | 80 | 82 | 78 | 75 | 78 | 78 | 83 | 71 | 64 |
| September | Min. | 45 | 48 | 50 | 47 | 54 | 52 | 62 | 68 | 64 | 56 | 54 | 45 | 45 | 52 | 53 | 56 | 58 | 56 | 50 | 62 | 58 | 52 | 54 | 46 | 58 | 56 | 50 | 36 | 36 | 41 | |
| | Max. | 64 | 62 | 70 | 89 | 87 | 84 | 80 | 86 | 71 | 64 | 74 | 77 | 76 | 80 | 86 | 89 | 66 | 70 | 83 | 86 | 62 | 58 | 74 | 76 | 72 | 73 | 57 | 59 | 74 | 81 | |
| October | Min. | 43 | 44 | 58 | 60 | 52 | 38 | 33 | 34 | 38 | 43 | 54 | 37 | 54 | 40 | 44 | 48 | 40 | 38 | 28 | 32 | 27 | 42 | 29 | 30 | 24 | 23 | 26 | 20 | 27 | 32 | 26 |
| | Max. | 85 | 80 | 84 | 70 | 58 | 64 | 71 | 72 | 78 | 67 | 65 | 65 | 61 | 60 | 68 | 52 | 64 | 60 | 57 | 44 | 52 | 61 | 62 | 60 | 48 | 51 | 46 | 32 | 43 | 40 | 48 |
| November | Min. | 19 | 20 | 26 | 40 | 28 | 32 | 32 | 23 | 28 | 31 | 23 | 30 | 24 | 23 | 22 | 16 | 20 | 28 | 21 | 36 | 30 | 24 | 25 | 29 | 20 | 14 | 29 | 26 | 20 | 32 | |
| | Max. | 34 | 50 | 55 | 64 | 73 | 52 | 36 | 37 | 47 | 49 | 40 | 42 | 50 | 40 | 42 | 40 | 43 | 43 | 53 | 66 | 53 | 50 | 35 | 37 | 47 | 42 | 35 | 35 | 50 | 49 | |
| December | Min. | 45 | 16 | 13 | 2 | 22 | 15 | 10 | —8 | —9 | —10 | 24 | 29 | 30 | —1 | —2 | 5 | 32 | 28 | 29 | 23 | 8 | 21 | 28 | 14 | 14 | 32 | 37 | 34 | 34 | 32 | 29 |
| | Max. | 52 | 26 | 27 | 22 | 40 | 19 | 26 | 28 | 35 | 36 | 54 | 38 | 42 | 43 | 40 | 35 | 52 | 37 | 35 | 37 | 36 | 36 | 47 | 40 | 43 | 41 | 46 | 40 | 42 | 42 | 43 |



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| DAYS. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MONTHS. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| January....Min. | 22 | 27 | 33 | 23 | 22 | 17 | 20 | 13 | 2 | 2 | 10 | 16 | 19 | 5 | 5 | 28 | 26 | 34 | 14 | 6 | 16 | 8 | 28 | 25 | 21 | 28 | 30 | 25 | 14 | 28 | 16 |
| Max. | 48 | 54 | 45 | 41 | 37 | 39 | 26 | 24 | 21 | 21 | 45 | 38 | 39 | 24 | 31 | 52 | 51 | 42 | 42 | 46 | 48 | 40 | 57 | 36 | 36 | 52 | 52 | 49 | 35 | 43 | 30 |
| February....Min. | 20 | 5 | 14 | 2 | 0 | 10 | 2 | 14 | 20 | 21 | 10 | 27 | 16 | 4 | 31 | 24 | 6 | 34 | 32 | 8 | 32 | 0 | 2 | 2 | 1 | 9 | 9 | 20 | | | |
| Max. | 39 | 20 | 24 | 17 | 26 | 36 | 32 | 28 | 29 | 31 | 25 | 49 | 37 | 26 | 58 | 31 | 34 | 43 | 28 | 39 | 30 | 22 | 37 | 35 | 24 | 32 | 34 | 36 | | | |
| March.....Min. | 27 | 18 | 12 | 0 | 8 | 11 | 19 | 9 | 12 | 18 | 6 | 9 | 11 | 14 | 7 | 14 | 22 | 22 | 13 | 11 | 32 | 32 | 29 | 19 | 11 | 9 | 25 | 28 | 33 | 36 | 25 |
| Max. | 39 | 36 | 33 | 28 | 36 | 39 | 35 | 47 | 45 | 38 | 29 | 21 | 19 | 51 | 64 | 39 | 33 | 48 | 53 | 67 | 49 | 49 | 39 | 34 | 46 | 54 | 37 | 42 | 53 | 54 | 65 |
| April.....Min. | 22 | 23 | 29 | 28 | 28 | 30 | 28 | 25 | 26 | 25 | 27 | 40 | 30 | 28 | 38 | 28 | 31 | 36 | 38 | 28 | 26 | 31 | 26 | 34 | 40 | 32 | 34 | 44 | 35 | 29 | |
| Max. | 66 | 64 | 47 | 47 | 48 | 47 | 58 | 70 | 70 | 69 | 75 | 60 | 64 | 84 | 72 | 59 | 44 | 54 | 49 | 46 | 44 | 61 | 70 | 80 | 66 | 70 | 83 | 86 | 73 | 80 | |
| May.....Min. | 34 | 36 | 32 | 45 | 33 | 32 | 34 | 37 | 42 | 37 | 37 | 34 | 39 | 32 | 43 | 47 | 46 | 35 | 42 | 59 | 45 | 45 | 32 | 43 | 40 | 45 | 41 | 42 | 48 | 49 | 50 |
| Max. | 75 | 79 | 83 | 83 | 70 | 75 | 67 | 66 | 50 | 52 | 47 | 62 | 66 | 69 | 89 | 83 | 72 | 75 | 84 | 87 | 76 | 67 | 72 | 44 | 74 | 72 | 72 | 62 | 78 | 85 | 76 |
| June.....Min. | 57 | 58 | 51 | 56 | 60 | 65 | 69 | 57 | 61 | 47 | 46 | 52 | 65 | 56 | 52 | 60 | 57 | 54 | 60 | 57 | 50 | 46 | 58 | 58 | 64 | 67 | 58 | 60 | 62 | 56 | |
| Max. | 86 | 91 | 87 | 92 | 89 | 85 | 80 | 71 | 64 | 57 | 62 | 78 | 83 | 82 | 87 | 84 | 83 | 92 | 82 | 88 | 80 | 68 | 78 | 96 | 99 | 67 | 79 | 92 | 88 | 88 | |
| July.....Min. | 53 | 46 | 56 | 49 | 58 | 57 | 65 | 64 | 54 | 52 | 61 | 62 | 60 | 72 | 56 | 53 | 70 | 64 | 64 | 58 | 67 | 55 | 58 | 70 | 78 | 66 | 70 | 56 | 64 | 58 | 53 |
| Max. | 74 | 80 | 78 | 80 | 74 | 92 | 88 | 76 | 79 | 88 | 98 | 88 | 88 | 99 | 86 | 88 | 96 | 88 | 93 | 88 | 93 | 88 | 95 | 100 | 96 | 92 | 86 | 90 | 87 | 83 | 87 |
| August.....Min. | 56 | 62 | 48 | 64 | 60 | 56 | 59 | 61 | 70 | 71 | 71 | 70 | 60 | 56 | 52 | 44 | 51 | 60 | 57 | 60 | 52 | 49 | 49 | 49 | 60 | 63 | 88 | 44 | 58 | 67 | 46 |
| Max. | 88 | 88 | 87 | 80 | 86 | 91 | 96 | 95 | 97 | 97 | 97 | 88 | 90 | 80 | 82 | 80 | 86 | 92 | 94 | 83 | 83 | 83 | 83 | 88 | 83 | 73 | 75 | 78 | 78 | 82 | 84 |
| September..Min. | 50 | 53 | 58 | 65 | 55 | 47 | 38 | 41 | 46 | 50 | 41 | 33 | 32 | 40 | 40 | 40 | 52 | 52 | 40 | 40 | 38 | 40 | 44 | 60 | 62 | 45 | 42 | 48 | 44 | 48 | |
| Max. | 90 | 88 | 76 | 87 | 73 | 72 | 76 | 72 | 80 | 72 | 66 | 79 | 79 | 85 | 86 | 68 | 65 | 72 | 76 | 84 | 84 | 85 | 84 | 76 | 78 | 76 | 76 | 78 | 76 | 62 | |
| October.....Min. | 50 | 44 | 48 | 46 | 50 | 48 | 30 | 28 | 30 | 34 | 37 | 58 | 48 | 38 | 29 | 40 | 46 | 56 | 34 | 42 | 40 | 30 | 38 | 26 | 38 | 24 | 18 | 42 | 34 | 29 | 34 |
| Max. | 73 | 76 | 58 | 69 | 71 | 54 | 66 | 74 | 72 | 78 | 77 | 64 | 68 | 70 | 71 | 80 | 75 | 65 | 58 | 54 | 62 | 66 | 63 | 70 | 76 | 59 | 46 | 59 | 49 | 61 | 42 |
| November...Min. | 30 | 22 | 42 | 34 | 28 | 26 | 22 | 22 | 38 | 32 | 26 | 42 | 36 | 30 | 28 | 20 | 28 | 22 | 28 | 28 | 27 | 27 | 27 | 30 | 23 | 28 | 34 | 34 | 32 | 27 | |
| Max. | 33 | 72 | 67 | 59 | 66 | 59 | 51 | 40 | 60 | 56 | 50 | 50 | 50 | 56 | 56 | 50 | 56 | 48 | 49 | 42 | 48 | 48 | 48 | 38 | 58 | 49 | 60 | 63 | 36 | 43 | |
| December...Min. | 15 | 37 | 30 | 22 | 27 | 36 | 33 | 35 | 28 | 24 | 20 | 34 | 34 | 32 | 27 | 14 | 16 | 19 | 15 | 20 | 22 | 8 | —1 | 1 | —5 | 2 | 12 | 11 | 22 | —2 | 15 |
| Max. | 58 | 58 | 43 | 54 | 43 | 43 | 52 | 39 | 40 | 35 | 38 | 41 | 46 | 47 | 29 | 28 | 36 | 35 | 42 | 48 | 38 | 29 | 19 | 21 | 19 | 28 | 30 | 32 | 22 | 30 | 48 |

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| DAYS. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MONTH. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| January.....Min. | 18 | 5 | 13 | 3 | —6 | 34 | 20 | —11 | —9 | —9 | —2 | 12 | 30 | 22 | 32 | 32 | 20 | 18 | 2 | 14 | 20 | —2 | —16 | —16 | —14 | —14 | 2 | 4 | 3 | 14 | 24 |
| Max. | 30 | 38 | 34 | 28 | 22 | 45 | 25 | 13 | 24 | 24 | 21 | 40 | 57 | 46 | 32 | 40 | 38 | 34 | 35 | 41 | 48 | 35 | 2 | 8 | 15 | 2 | 33 | 28 | 25 | 43 | 43 |
| February....Min. | 26 | 20 | 10 | —1 | —16 | —7 | —1 | 14 | 24 | 16 | 6 | 2 | 2 | —9 | 2 | 4 | 20 | 23 | 12 | 16 | 10 | —3 | —3 | 26 | 36 | 33 | 30 | 20 | | | |
| Max. | 47 | 42 | 31 | 3 | 2 | 25 | 43 | 31 | 43 | 38 | 28 | 17 | 39 | 23 | 37 | 38 | 47 | 46 | 33 | 41 | 35 | 34 | 46 | 54 | 58 | 57 | 44 | 34 | | | |
| March.....Min. | 30 | 28 | 28 | 23 | 28 | 28 | 22 | 33 | 45 | 28 | 54 | 35 | 30 | 26 | 33 | 28 | 32 | 34 | 24 | 24 | 30 | 31 | 28 | 26 | 26 | 25 | 29 | 21 | 16 | 21 | 29 |
| Max. | 54 | 48 | 40 | 50 | 54 | 50 | 64 | 62 | 50 | 66 | 65 | 68 | 58 | 44 | 44 | 42 | 42 | 48 | 58 | 48 | 40 | 40 | 52 | 34 | 40 | 50 | 30 | 39 | 38 | 56 | 48 |
| April.....Min. | 19 | 28 | 28 | 34 | 32 | 22 | 27 | 51 | 40 | 36 | 36 | 34 | 30 | 30 | 32 | 34 | 32 | 28 | 30 | 36 | 34 | 40 | 40 | 34 | 26 | 36 | 30 | 34 | 38 | 32 | |
| Max. | 49 | 56 | 53 | 56 | 50 | 57 | 80 | 92 | 61 | 68 | 58 | 50 | 59 | 63 | 62 | 58 | 49 | 60 | 62 | 54 | 74 | 59 | 52 | 57 | 60 | 63 | 55 | 70 | 55 | 57 | |
| May.....Min. | 34 | 40 | 40 | 34 | 34 | 33 | 40 | 36 | 40 | 36 | 28 | 37 | 43 | 35 | 40 | 31 | 57 | 38 | 35 | 47 | 55 | 53 | 53 | 44 | 34 | 62 | 58 | 45 | 47 | 64 | 58 |
| Max. | 59 | 63 | 65 | 52 | 40 | 56 | 54 | 52 | 62 | 59 | 62 | 79 | 62 | 54 | 64 | 75 | 67 | 65 | 74 | 90 | 93 | 75 | 65 | 65 | 84 | 79 | 72 | 71 | 93 | 95 | 88 |
| June.....Min. | 46 | 53 | 62 | 69 | 57 | 44 | 57 | 67 | 60 | 43 | 56 | 60 | 50 | 48 | 48 | 43 | 42 | 44 | 49 | 50 | 53 | 57 | 51 | 46 | 43 | 50 | 52 | 58 | 58 | 43 | |
| Max. | 82 | 92 | 95 | 85 | 82 | 84 | 75 | 80 | 70 | 77 | 77 | 66 | 72 | 67 | 66 | 71 | 70 | 58 | 68 | 83 | 71 | 72 | 76 | 58 | 76 | 83 | 83 | 82 | 77 | 69 | |
| July..... Min. | 44 | 54 | 59 | 54 | 60 | 58 | 67 | 60 | 62 | 72 | 58 | 62 | 56 | 61 | 60 | 58 | 52 | 46 | 58 | 58 | 45 | 51 | 41 | 46 | 50 | 55 | 57 | 59 | 62 | 62 | 64 |
| Max. | 78 | 79 | 84 | 76 | 83 | 88 | 84 | 82 | 88 | 84 | 75 | 83 | 88 | 85 | 88 | 80 | 76 | 77 | 82 | 71 | 75 | 69 | 71 | 77 | 72 | 72 | 80 | 80 | 74 | 73 | 75 |
| August.....Min. | 61 | 54 | 51 | 58 | 68 | 57 | 60 | 61 | 60 | 58 | 52 | 57 | 57 | 49 | 57 | 67 | 63 | 44 | 52 | 41 | 50 | 55 | 46 | 61 | 69 | 58 | 55 | 58 | 58 | 61 | 56 |
| Max. | 78 | 78 | 84 | 83 | 85 | 80 | 85 | 80 | 80 | 87 | 82 | 87 | 79 | 82 | 78 | 81 | 88 | 88 | 70 | 69 | 65 | 73 | 78 | 83 | 85 | 75 | 84 | 83 | 65 | 86 | 73 |
| September..Min. | 45 | 47 | 47 | 52 | 53 | 58 | 61 | 41 | 35 | 42 | 47 | 41 | 45 | 39 | 33 | 45 | 45 | 38 | 32 | 48 | 35 | 25 | 29 | 45 | 40 | 43 | 47 | 32 | 38 | 36 | |
| Max. | 77 | 82 | 86 | 84 | 85 | 85 | 72 | 72 | 74 | 80 | 75 | 75 | 71 | 64 | 57 | 62 | 65 | 61 | 62 | 59 | 62 | 62 | 70 | 74 | 76 | 57 | 65 | 59 | 58 | 63 | |
| October.....Min. | 26 | 42 | 47 | 42 | 35 | 37 | 49 | 36 | 33 | 40 | 60 | 50 | 36 | 28 | 46 | 44 | 29 | 31 | 25 | 27 | 20 | 35 | 55 | 40 | 26 | 42 | 45 | 32 | 34 | 30 | 34 |
| Max. | 59 | 54 | 59 | 68 | 73 | 63 | 76 | 78 | 75 | 58 | 67 | 63 | 68 | 60 | 75 | 68 | 64 | 64 | 43 | 47 | 56 | 75 | 75 | 55 | 55 | 50 | 60 | 48 | 51 | 62 | 59 |
| November...Min. | 39 | 27 | 28 | 22 | 21 | 21 | 22 | 23 | 28 | 15 | 26 | 20 | 12 | 12 | 30 | 32 | 28 | 21 | 21 | 23 | 30 | 28 | 22 | 13 | 29 | 25 | 33 | —2 | 4 | —2 | |
| Max. | 68 | 55 | 50 | 53 | 53 | 44 | 46 | 44 | 48 | 35 | 44 | 44 | 57 | 37 | 44 | 37 | 56 | 64 | 53 | 41 | 47 | 48 | 43 | 37 | 45 | 42 | 41 | 21 | 17 | 19 | |
| December...Min. | 5 | 8 | 10 | 29 | 12 | —2 | 6 | 24 | 11 | 8 | 21 | 20 | 4 | 10 | —2 | —10 | 12 | 20 | 17 | 17 | —13 | —16 | 6 | 37 | 22 | 28 | 26 | 0 | 4 | —1 | 9 |
| Max. | 24 | 34 | 49 | 43 | 22 | 27 | 31 | 31 | 27 | 24 | 38 | 34 | 27 | 29 | 23 | 32 | 51 | 29 | 29 | 22 | 3 | 13 | 50 | 57 | 50 | 43 | 48 | 28 | 28 | 25 | 25 |

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| Days. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Months. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| January.....Min. | 32 | 11 | 8 | 16 | 27 | 25 | −6 | 0 | 12 | 31 | 12 | 24 | 24 | 10 | 1 | 6 | 14 | 14 | 28 | 22 | 24 | 24 | 24 | 7 | 2 | 8 | 9 | 16 | 10 | 0 | 0 |
| Max. | 44 | 47 | 19 | 37 | 48 | 41 | 16 | 30 | 39 | 39 | 35 | 51 | 50 | 20 | 20 | 24 | 22 | 24 | 37 | 48 | 38 | 43 | 44 | 27 | 28 | 29 | 30 | 48 | 23 | 26 | 34 |
| February..Min. | −3 | −8 | −6 | 12 | 7 | 11 | 12 | −4 | −4 | 8 | 10 | 14 | 15 | 29 | 3 | 19 | 12 | −8 | 2 | 5 | 15 | 10 | −5 | 17 | 21 | 7 | 5 | 9 | 3 | | |
| Max. | 32 | 45 | 19 | 35 | 49 | 47 | 36 | 46 | 39 | 34 | 54 | 64 | 50 | 40 | 33 | 47 | 49 | 48 | 60 | 64 | 64 | 18 | 38 | 62 | 40 | 19 | 24 | 29 | 30 | | |
| March.....Min. | 3 | 1 | 18 | 15 | −16 | −11 | −3 | 10 | 5 | 25 | 28 | 21 | 6 | 22 | 30 | 5 | 5 | 16 | 12 | 1 | −2 | 7 | 4 | 20 | 17 | 25 | 25 | 19 | 18 | 13 | 22 |
| Max. | 31 | 25 | 43 | 37 | −2 | 5 | 35 | 34 | 32 | 34 | 54 | 25 | 44 | 58 | 30 | 35 | 32 | 34 | 45 | 11 | 28 | 31 | 32 | 44 | 50 | 44 | 60 | 47 | 37 | 52 | 30 |
| April.....Min | 24 | 24 | 28 | 28 | 28 | 27 | 27 | 34 | 36 | 36 | 35 | 32 | 41 | 35 | 28 | 32 | 30 | 24 | 33 | 29 | 35 | 38 | 28 | 31 | 33 | 58 | 50 | 38 | 38 | 33 | |
| Max. | 36 | 47 | 50 | 55 | 58 | 60 | 49 | 52 | 41 | 52 | 48 | 66 | 66 | 48 | 57 | 47 | 60 | 66 | 65 | 77 | 81 | 52 | 50 | 65 | 68 | 85 | 66 | 60 | 74 | 77 | |
| May.....Min. | 40 | 47 | 49 | 43 | 40 | 44 | 43 | 44 | 54 | 73 | 48 | 45 | 48 | 41 | 51 | 37 | 40 | 38 | 45 | 54 | 45 | 41 | 53 | 52 | 55 | 51 | 46 | 53 | 42 | 45 | 55 |
| Max. | 67 | 75 | 77 | 60 | 63 | 58 | 82 | 82 | 83 | 81 | 68 | 80 | 72 | 72 | 70 | 64 | 72 | 76 | 58 | 72 | 70 | 76 | 61 | 73 | 74 | 74 | 77 | 64 | 62 | 68 | 65 |
| June.....Min | 50 | 46 | 42 | 47 | 50 | 50 | 51 | 59 | 59 | 63 | 60 | 62 | 61 | 61 | 56 | 57 | 54 | 56 | 66 | 67 | 68 | 71 | 65 | 60 | 65 | 63 | 63 | 68 | 64 | 73 | |
| Max. | 70 | 66 | 70 | 70 | 54 | 65 | 77 | 59 | 77 | 69 | 79 | 86 | 79 | 82 | 78 | 79 | 83 | 84 | 87 | 80 | 98 | 94 | 82 | 78 | 72 | 70 | 74 | 82 | 92 | 96 | |
| July.....Min. | 73 | 76 | 64 | 72 | 72 | 62 | 62 | 67 | 61 | 72 | 72 | 64 | 64 | 55 | 65 | 72 | 72 | 70 | 68 | 57 | 59 | 67 | 54 | 63 | 61 | 58 | 59 | 50 | 64 | 66 | 51 |
| Max | 96 | 92 | 88 | 95 | 90 | 88 | 87 | 88 | 89 | 89 | 88 | 92 | 80 | 86 | 94 | 93 | 93 | 78 | 88 | 83 | 84 | 85 | 86 | 81 | 80 | 76 | 78 | 80 | 82 | 80 | 79 |
| August.....Min. | 56 | 56 | 64 | 61 | 56 | 57 | 63 | 68 | 68 | 68 | 71 | 72 | 69 | 69 | 69 | 69 | 69 | 68 | 72 | 66 | 63 | 63 | 65 | 57 | 63 | 66 | 68 | 58 | 49 | 57 | 53 |
| Max. | 80 | 78 | 69 | 81 | 84 | 85 | 91 | 94 | 97 | 94 | 89 | 84 | 84 | 88 | 88 | 89 | 85 | 90 | 90 | 87 | 73 | 75 | 88 | 86 | 85 | 86 | 76 | 78 | 80 | 58 | 65 |
| September..Min. | 57 | 53 | 48 | 45 | 40 | 52 | 63 | 68 | 70 | 59 | 55 | 61 | 64 | 62 | 52 | 54 | 57 | 55 | 54 | 50 | 48 | 46 | 62 | 61 | 64 | 67 | 62 | 49 | 45 | 59 | |
| Max. | 70 | 77 | 62 | 67 | 68 | 80 | 86 | 96 | 74 | 79 | 63 | 77 | 73 | 72 | 64 | 59 | 61 | 71 | 69 | 64 | 70 | 88 | 80 | 80 | 82 | 70 | 62 | 73 | 65 | 76 | |
| October.....Min. | 55 | 50 | 42 | 42 | 33 | 53 | 59 | 58 | 44 | 39 | 38 | 28 | 35 | 42 | 35 | 37 | 31 | 45 | 41 | 36 | 29 | 36 | 49 | 40 | 33 | 45 | 50 | 37 | 25 | 24 | 29 |
| Max. | 63 | 58 | 56 | 64 | 68 | 72 | 71 | 60 | 68 | 78 | 46 | 51 | 49 | 56 | 52 | 55 | 58 | 51 | 63 | 50 | 70 | 74 | 64 | 68 | 57 | 49 | 55 | 67 | 68 | 67 | 54 |
| November...Min. | 42 | 42 | 37 | 30 | 21 | 33 | 46 | 38 | 39 | 33 | 25 | 41 | 35 | 27 | 35 | 22 | 21 | 21 | 21 | 32 | 15 | 24 | 26 | 31 | 27 | 30 | 19 | 21 | 25 | 10 | |
| Max. | 49 | 52 | 42 | 66 | 63 | 48 | 46 | 50 | 53 | 60 | 48 | 55 | 42 | 45 | 55 | 52 | 45 | 44 | 49 | 42 | 41 | 39 | 48 | 50 | 47 | 35 | 54 | 49 | 32 | 24 | |
| December..Min. | 14 | 22 | 22 | 29 | 11 | 25 | 16 | 10 | 22 | 7 | 9 | −5 | 0 | 15 | 18 | 4 | 19 | −2 | 21 | 12 | 23 | 7 | −5 | −1 | −20 | −10 | −1 | −9 | −15 | −8 | −8 |
| Max. | 34 | 49 | 42 | 42 | 32 | 44 | 46 | 35 | 33 | 19 | 33 | 11 | 42 | 42 | 47 | 26 | 42 | 22 | 42 | 32 | 43 | 15 | 17 | 28 | 8 | 2 | 5 | 24 | 14 | 24 | 12 |

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| Days. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Months. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| January.....Min. | —9 | —13 | 17 | 31 | 7 | 31 | —2 | —11 | 28 | —8 | —21 | —9 | —12 | 20 | 1 | 13 | 26 | 20 | 18 | —1 | 19 | 21 | 11 | 5 | 12 | 0 | 1 | 12 | —8 | —26 | 0 |
| Max. | 37 | 18 | 37 | 44 | 37 | 39 | 42 | 17 | 38 | 30 | 21 | 31 | 12 | 47 | 19 | 28 | 46 | 26 | 34 | 31 | 31 | 36 | 31 | 11 | 24 | 32 | 21 | 32 | 8 | 16 | 44 |
| February...Min. | 13 | —9 | —12 | 13 | 22 | —1 | 9 | 29 | 9 | —9 | —8 | —7 | 2 | —14 | —9 | 3 | 21 | 5 | 19 | 21 | 3 | 11 | 3 | —12 | 4 | 22 | 4 | 25 | | | |
| Max. | 28 | 23 | 36 | 46 | 48 | 54 | 48 | 48 | 31 | 14 | 15 | 43 | 41 | 33 | 49 | 27 | 50 | 47 | 36 | 36 | 21 | 25 | 18 | 14 | 42 | 48 | 40 | 45 | | | |
| March.....Min. | 27 | 14 | 19 | 13 | 0 | —7 | 1 | 20 | 25 | 18 | —1 | 14 | 27 | 23 | 16 | 26 | 20 | 19 | 21 | 18 | 25 | 19 | 21 | 8 | 5 | 15 | 10 | 8 | 25 | 30 | 27 |
| Max. | 39 | 40 | 30 | 31 | 5 | 47 | 61 | 52 | 35 | 35 | 35 | 52 | 47 | 51 | 32 | 42 | 38 | 41 | 48 | 34 | 44 | 41 | 37 | 24 | 25 | 27 | 35 | 52 | 46 | 43 | 44 |
| April.....Min. | 26 | 28 | 26 | 30 | 24 | 27 | 28 | 29 | 30 | 28 | 21 | 28 | 28 | 28 | 31 | 25 | 34 | 28 | 30 | 32 | 31 | 24 | 26 | 23 | 31 | 30 | 31 | 29 | 28 | 29 | |
| Max. | 61 | 38 | 46 | 54 | 42 | 42 | 40 | 43 | 42 | 55 | 67 | 46 | 36 | 41 | 56 | 65 | 54 | 40 | 56 | 56 | 57 | 55 | 59 | 61 | 50 | 51 | 59 | 65 | 68 | 74 | |
| May.....Min. | 36 | 40 | 30 | 40 | 38 | 30 | 28 | 30 | 36 | 38 | 44 | 44 | 44 | 32 | 35 | 32 | 44 | 42 | 34 | 40 | 40 | 45 | 55 | 60 | 50 | 54 | 57 | 60 | 62 | 53 | 35 |
| Max. | 75 | 53 | 38 | 66 | 68 | 68 | 75 | 66 | 53 | 54 | 51 | 68 | 72 | 58 | 59 | 64 | 62 | 63 | 68 | 72 | 70 | 57 | 77 | 82 | 82 | 84 | 88 | 86 | 82 | 66 | 67 |
| June.....Min. | 42 | 54 | 48 | 48 | 63 | 51 | 56 | 55 | 45 | 48 | 62 | 57 | 44 | 46 | 58 | 61 | 61 | 49 | 61 | 69 | 55 | 46 | 50 | 50 | 50 | 54 | 58 | 65 | 66 | 71 | |
| Max. | 78 | 72 | 72 | 72 | 78 | 78 | 71 | 72 | 77 | 79 | 79 | 71 | 73 | 73 | 79 | 86 | 75 | 77 | 89 | 87 | 71 | 72 | 76 | 78 | 83 | 88 | 88 | 88 | 90 | 85 | |
| July.....Min. | 70 | 72 | 71 | 70 | 70 | 70 | 50 | 53 | 59 | 58 | 59 | 50 | 54 | 71 | 69 | 62 | 59 | 54 | 51 | 55 | 55 | 51 | 60 | 72 | 59 | 69 | 71 | 64 | 69 | 73 | 64 |
| Max. | 79 | 88 | 88 | 88 | 88 | 74 | 87 | 75 | 76 | 79 | 70 | 74 | 88 | 88 | 91 | 74 | 64 | 58 | 57 | 74 | 80 | 81 | 86 | 86 | 86 | 93 | 77 | 83 | 82 | 87 | 86 |
| August.....Min. | 67 | 68 | 66 | 62 | 53 | 53 | 61 | 61 | 53 | 50 | 50 | 59 | 49 | 49 | 64 | 55 | 60 | 58 | 60 | 59 | 61 | 62 | 62 | 52 | 54 | 53 | 47 | 45 | 47 | 60 | 62 |
| Max. | 84 | 85 | 89 | 79 | 78 | 80 | 78 | 83 | 77 | 75 | 78 | 71 | 72 | 60 | 65 | 80 | 78 | 72 | 74 | 75 | 73 | 73 | 77 | 67 | 74 | 71 | 77 | 79 | 79 | 82 | 75 |
| September..Min. | 59 | 56 | 52 | 53 | 62 | 55 | 39 | 55 | 40 | 43 | 54 | 51 | 55 | 52 | 39 | 49 | 39 | 44 | 59 | 47 | 39 | 35 | 45 | 54 | 53 | 58 | 44 | 57 | 61 | 51 | |
| Max. | 64 | 72 | 72 | 63 | 84 | 69 | 68 | 67 | 68 | 69 | 73 | 83 | 82 | 54 | 64 | 71 | 66 | 71 | 68 | 61 | 64 | 64 | 57 | 70 | 65 | 75 | 82 | 90 | 80 | 58 | |
| October.....Min. | 32 | 38 | 33 | 41 | 53 | 47 | 47 | 36 | 37 | 31 | 33 | 37 | 4 | 33 | 34 | 34 | 46 | 28 | 52 | 61 | 60 | 39 | 33 | 44 | 39 | 28 | 50 | 34 | 32 | 27 | 36 |
| Max. | 62 | 63 | 64 | 51 | 70 | 69 | 49 | 63 | 67 | 73 | 77 | 73 | 58 | 60 | 68 | 74 | 71 | 63 | 75 | 65 | 73 | 66 | 78 | 70 | 61 | 63 | 61 | 67 | 49 | 55 | 43 |
| November...Min. | 37 | 30 | 43 | 22 | 36 | 26 | 15 | 36 | 41 | 26 | 20 | 26 | 30 | 12 | 7 | 14 | 23 | 26 | 18 | 2 | 4 | 8 | 3 | 22 | 23 | 11 | 1 | —5 | —9 | 4 | |
| Max. | 48 | 57 | 55 | 56 | 53 | 53 | 48 | 44 | 46 | 43 | 50 | 37 | 37 | 36 | 31 | 26 | 30 | 34 | 41 | 47 | 28 | 43 | 51 | 28 | 23 | 23 | 15 | 23 | 35 | 34 | |
| December...Min. | —6 | —8 | 14 | 44 | 32 | 17 | 9 | 2 | 33 | 34 | 16 | 26 | 33 | 19 | 23 | 11 | 16 | 17 | 17 | 17 | 5 | —4 | —1 | 2 | 29 | 14 | 18 | 26 | 23 | 13 | 2 |
| Max. | 28 | 15 | 40 | 58 | 37 | 37 | 45 | 30 | 47 | 41 | 33 | 38 | 33 | 37 | 30 | 47 | 53 | 48 | 31 | 44 | 38 | 40 | 29 | 47 | 35 | 26 | 30 | 32 | 30 | 28 | 39 |

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| Days. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Months. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| January.....Min. | 18 | 27 | 32 | 36 | 28 | 22 | 32 | 30 | 45 | 24 | 27 | 22 | 10 | 17 | 5 | —2 | —1 | —4 | 14 | 21 | 3 | 25 | 36 | 20 | 4 | —14 | —3 | —1 | 12 | —4 | —7 |
| Max. | 46 | 35 | 41 | 66 | 42 | 40 | 40 | 55 | 62 | 50 | 42 | 36 | 21 | 19 | 18 | 36 | 36 | 52 | 39 | 42 | 19 | 36 | 58 | 35 | 18 | 18 | 24 | 30 | 36 | 17 | 11 |
| February....Min. | —5 | —28 | —4 | 22 | 1 | —6 | 6 | 5 | —2 | 12 | 12 | 4 | 12 | 35 | 16 | 26 | 22 | 6 | 0 | 31 | 33 | 34 | 31 | 23 | 12 | 13 | 19 | —7 | | | |
| Max. | 18 | 30 | 27 | 36 | 23 | 20 | 32 | 34 | 45 | 43 | 32 | 44 | 50 | 48 | 38 | 38 | 34 | 44 | 36 | 55 | 36 | 40 | 35 | 30 | 23 | 40 | 40 | 40 | | | |
| March.....Min. | 3 | 23 | 30 | 46 | 17 | 18 | 26 | 23 | 29 | 15 | 18 | 2 | 2 | 11 | 16 | 16 | 31 | 35 | 45 | 36 | 20 | 34 | 23 | —3 | 10 | 31 | 26 | 29 | 22 | 19 | 19 |
| Max. | 54 | 64 | 62 | 58 | 47 | 43 | 29 | 45 | 36 | 22 | 18 | 18 | 24 | 35 | 47 | 58 | 40 | 63 | 61 | 50 | 55 | 47 | 35 | 23 | 50 | 55 | 52 | 43 | 38 | 49 | 27 |
| April.....Min. | 7 | 21 | 24 | 24 | 12 | 26 | 30 | 26 | 33 | 30 | 23 | 13 | 10 | 24 | 46 | 38 | 29 | 18 | 27 | 33 | 31 | 32 | 29 | 31 | 28 | 28 | 33 | 31 | 33 | 28 | |
| Max. | 48 | 55 | 46 | 35 | 44 | 46 | 51 | 61 | 41 | 45 | 41 | 30 | 46 | 68 | 66 | 50 | 40 | 58 | 67 | 36 | 50 | 55 | 38 | 50 | 42 | 40 | 52 | 49 | 37 | 39 | |
| May.....Min. | 34 | 33 | 36 | 32 | 35 | 30 | 36 | 30 | 36 | 48 | 44 | 30 | 43 | 60 | 42 | 48 | 47 | 45 | 49 | 38 | 50 | 48 | 40 | 48 | 52 | 52 | 46 | 50 | 59 | 56 | 60 |
| Max. | 47 | 49 | 64 | 68 | 64 | 60 | 56 | 63 | 60 | 76 | 69 | 74 | 83 | 78 | 76 | 50 | 74 | 61 | 63 | 70 | 52 | 58 | 69 | 73 | 59 | 66 | 78 | 87 | 85 | 84 | 90 |
| June.....Min | 60 | 47 | 49 | 51 | 58 | 66 | 62 | 65 | 57 | 57 | 52 | 52 | 44 | 44 | 52 | 56 | 56 | 60 | 59 | 51 | 56 | 56 | 64 | 61 | 54 | 56 | 49 | 49 | 70 | 67 | |
| Max. | 65 | 68 | 70 | 69 | 76 | 72 | 72 | 80 | 80 | 75 | 64 | 60 | 62 | 76 | 78 | 76 | 73 | 68 | 65 | 64 | 72 | 80 | 85 | 69 | 74 | 74 | 80 | 90 | 93 | 90 | |
| July .....Min. | 57 | 61 | 61 | 60 | 55 | 50 | 59 | 71 | 66 | 61 | 68 | 58 | 57 | 57 | 64 | 73 | 62 | 55 | 60 | 65 | 67 | 53 | 53 | 57 | 59 | 6 | 67 | 65 | 65 | 62 | 55 |
| Max. | 83 | 76 | 76 | 76 | 59 | 72 | 86 | 88 | 85 | 78 | 75 | 62 | 71 | 85 | 92 | 86 | 80 | 81 | 88 | 78 | 78 | 80 | 80 | 85 | 84 | 82 | 83 | 88 | 71 | 82 | 81 |
| August .....Min. | 61 | 57 | 54 | 47 | 51 | 51 | 51 | 66 | 64 | 59 | 62 | 64 | 69 | 63 | 60 | 53 | 53 | 51 | 54 | 60 | 64 | 60 | 41 | 49 | 46 | 44 | 45 | 47 | 54 | 55 | 52 |
| Max. | 73 | 78 | 66 | 73 | 77 | 77 | 77 | 75 | 69 | 87 | 88 | 87 | 76 | 64 | 78 | 79 | 81 | 83 | 85 | 82 | 76 | 77 | 75 | 73 | 73 | 76 | 75 | 78 | 79 | 77 | 82 |
| September...Min. | 58 | 52 | 52 | 44 | 44 | 56 | 54 | 49 | 49 | 52 | 64 | 55 | 44 | 50 | 53 | 59 | 59 | 54 | 54 | 56 | 55 | 39 | 39 | 44 | 50 | 60 | 58 | 47 | 52 | 56 | |
| Max. | 80 | 80 | 84 | 99 | 74 | 79 | 69 | 76 | 77 | 88 | 78 | 73 | 72 | 78 | 78 | 78 | 70 | 65 | 60 | 65 | 69 | 69 | 74 | 76 | 80 | 82 | 60 | 70 | 63 | 62 | |
| October.....Min. | 41 | 42 | 44 | 32 | 31 | 37 | 47 | 53 | 47 | 42 | 50 | 40 | 32 | 38 | 34 | 32 | 32 | 51 | 38 | 32 | 48 | 24 | 29 | 37 | 37 | 37 | 40 | 42 | 50 | 42 | 40 |
| Max. | 57 | 58 | 60 | 57 | 63 | 60 | 60 | 66 | 65 | 58 | 64 | 56 | 56 | 55 | 62 | 70 | 70 | 62 | 46 | 68 | 70 | 74 | 70 | 71 | 82 | 83 | 60 | 69 | 74 | 65 | 60 |
| November...Min. | 36 | 31 | 19 | 22 | 22 | 42 | 46 | 25 | 35 | 31 | 35 | 28 | 22 | 18 | 11 | 26 | 28 | 38 | 20 | 13 | 26 | 17 | 17 | 32 | 21 | 19 | 9 | 20 | 51 | 15 | |
| Max | 50 | 60 | 58 | 63 | 56 | 65 | 66 | 63 | 47 | 65 | 56 | 42 | 37 | 48 | 33 | 54 | 42 | 65 | 43 | 29 | 38 | 39 | 39 | 39 | 32 | 55 | 55 | 57 | 52 | 28 | |
| December....Min. | 2 | 19 | 24 | 26 | 9 | 21 | 31 | 29 | 11 | 27 | 17 | 6 | 5 | 23 | —14 | —7 | 9 | 10 | 22 | 16 | 16 | —3 | 25 | 30 | 27 | 4 | 12 | 26 | 37 | 9 | 14 |
| Max. | 28 | 38 | 48 | 44 | 35 | 36 | 37 | 44 | 35 | 48 | 42 | 30 | 27 | 31 | 8 | 37 | 28 | 30 | 39 | 29 | 42 | 31 | 46 | 45 | 43 | 30 | 55 | 38 | 45 | 21 | 16 |

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| Days. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Months. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| January.....Min. | —4 | 3 | 20 | 2 | —5 | —12 | 12 | 21 | 10 | —10 | —23 | —21 | —2 | 15 | —3 | —7 | —8 | —7 | —11 | —26 | —23 | —2 | —2 | —13 | 10 | 2 | 2 | —11 | 21 | 18 | 0 |
| Max. | 30 | 32 | 38 | 28 | 26 | 36 | 26 | 36 | 22 | 10 | 33 | 39 | 22 | 18 | 13 | 18 | 18 | 6 | 28 | 26 | 15 | 27 | 35 | 15 | 34 | 31 | 30 | 29 | 34 | 42 | 28 |
| February.....Min. | 21 | 15 | 10 | 15 | —1 | 5 | —18 | —7 | —14 | —7 | —2 | —34 | —29 | —13 | —9 | —12 | —18 | 0 | —21 | —20 | —20 | —8 | 25 | 35 | 32 | 24 | 8 | 1 | | | |
| Max. | 35 | 39 | 41 | 32 | 25 | 21 | 16 | 20 | —2 | 33 | 8 | 22 | 15 | 13 | 25 | 32 | 26 | 26 | 27 | 35 | 35 | 36 | 63 | 45 | 40 | 32 | 20 | 15 | | | |
| March .....Min. | —7 | 7 | 4 | 10 | —11 | 21 | 28 | 27 | 16 | 22 | 7 | 26 | 22 | 10 | 36 | 33 | 27 | 7 | 8 | 12 | 11 | —4 | —10 | —16 | 24 | 16 | 30 | 26 | 13 | 21 | 24 |
| Max. | 13 | 35 | 18 | 22 | 32 | 38 | 42 | 53 | 36 | 34 | 47 | 54 | 44 | 53 | 42 | 40 | 38 | 23 | 32 | 20 | 31 | 32 | 44 | 30 | 37 | 45 | 54 | 50 | 54 | 63 | 49 |
| April.....Min. | 31 | 33 | 40 | 36 | 36 | 30 | 23 | 22 | 28 | 27 | 29 | 34 | 31 | 27 | 26 | 38 | 26 | 20 | 16 | 16 | 14 | 22 | 33 | 31 | 40 | 40 | 32 | 28 | 29 | 40 | |
| Max. | 48 | 57 | 50 | 38 | 56 | 46 | 55 | 43 | 48 | 60 | 61 | 42 | 34 | 57 | 61 | 49 | 42 | 40 | 36 | 34 | 34 | 50 | 67 | 68 | 58 | 58 | 70 | 71 | 71 | 55 | |
| May.....Min. | 35 | 38 | 36 | 34 | 36 | 44 | 42 | 36 | 41 | 44 | 40 | 48 | 44 | 42 | 44 | 42 | 35 | 33 | 46 | 45 | 46 | 53 | 60 | 49 | 63 | 62 | 48 | 45 | 47 | 53 | 51 |
| Max. | 59 | 53 | 55 | 62 | 70 | 61 | 66 | 55 | 55 | 66 | 75 | 75 | 73 | 71 | 53 | 52 | 73 | 68 | 56 | 64 | 82 | 85 | 87 | 89 | 87 | 83 | 80 | 82 | 75 | 68 | 78 |
| June.....Min. | 48 | 50 | 44 | 57 | 53 | 66 | 56 | 53 | 56 | 55 | 51 | 59 | 55 | 38 | 48 | 43 | 43 | 50 | 50 | 50 | 54 | 68 | 70 | 74 | 55 | 63 | 73 | 56 | 59 | 50 | |
| Max. | 76 | 74 | 78 | 81 | 87 | 77 | 58 | 75 | 68 | 73 | 81 | 83 | 61 | 68 | 72 | 78 | 72 | 52 | 65 | 76 | 82 | 88 | 80 | 90 | 86 | 81 | 85 | 90 | 74 | 83 | |
| July.....Min. | 66 | 51 | 50 | 57 | 68 | 70 | 70 | 68 | 60 | 60 | 65 | 53 | 54 | 59 | 59 | 67 | 64 | 53 | 53 | 45 | 55 | 58 | 64 | 57 | 53 | 56 | 66 | 65 | 57 | 62 | 57 |
| Max. | 75 | 77 | 82 | 74 | 88 | 89 | 75 | 78 | 88 | 78 | 79 | 79 | 82 | 81 | 85 | 73 | 78 | 65 | 73 | 78 | 81 | 82 | 68 | 81 | 84 | 79 | 86 | 80 | 84 | 90 | 76 |
| August.....Min. | 53 | 56 | 58 | 56 | 67 | 63 | 69 | 70 | 62 | 59 | 59 | 70 | 73 | 70 | 64 | 69 | 67 | 66 | 68 | 55 | 62 | 59 | 58 | 52 | 56 | 51 | 52 | 50 | 54 | 62 | 62 |
| Max. | 75 | 70 | 60 | 72 | 79 | 81 | 83 | 84 | 84 | 83 | 80 | 83 | 88 | 86 | 87 | 89 | 74 | 69 | 86 | 85 | 84 | 83 | 74 | 78 | 78 | 82 | 83 | 87 | 87 | 89 | 89 |
| September..Min. | 60 | 58 | 64 | 67 | 64 | 60 | 54 | 50 | 58 | 68 | 42 | 36 | 45 | 46 | 49 | 52 | 52 | 42 | 40 | 35 | 36 | 38 | 30 | 29 | 34 | 52 | 42 | 50 | 35 | 46 | |
| Max. | 88 | 87 | 86 | 88 | 77 | 77 | 75 | 82 | 90 | 75 | 70 | 65 | 71 | 70 | 75 | 70 | 63 | 58 | 53 | 60 | 56 | 56 | 59 | 67 | 70 | 58 | 68 | 66 | 46 | 70 | |
| October.....Min. | 46 | 40 | 31 | 49 | 54 | 43 | 41 | 42 | 39 | 40 | 46 | 28 | 26 | 22 | 38 | 47 | 41 | 39 | 45 | 32 | 50 | 38 | 34 | 44 | 41 | 35 | 42 | 38 | 32 | 34 | 37 |
| Max. | 50 | 58 | 65 | 72 | 68 | 47 | 62 | 68 | 62 | 58 | 58 | 45 | 54 | 69 | 49 | 54 | 53 | 68 | 69 | 66 | 73 | 75 | 66 | 50 | 71 | 52 | 52 | 56 | 43 | 49 | 45 |
| November..Min. | 24 | 27 | 25 | 28 | 24 | 22 | 24 | 24 | 22 | 27 | 28 | 28 | 30 | 33 | 26 | 28 | 24 | 12 | 24 | 18 | 24 | 12 | 4 | 22 | 14 | 2 | 35 | 15 | 25 | —17 | |
| Max. | 35 | 37 | 52 | 47 | 55 | 55 | 52 | 60 | 64 | 41 | 49 | 58 | 62 | 36 | 35 | 37 | 29 | 40 | 43 | 46 | 35 | 40 | 23 | 45 | 47 | 30 | 50 | 35 | 39 | 7 | |
| December....Min. | —14 | —5 | —6 | 14 | 12 | 20 | 9 | 29 | 29 | 26 | 18 | 25 | 15 | 17 | 7 | 11 | 25 | 0 | —22 | —24 | 25 | 40 | 42 | 20 | 18 | 26 | 34 | 9 | 22 | 32 | 32 |
| Max. | 25 | 28 | 44 | 50 | 42 | 42 | 31 | 35 | 33 | 52 | 37 | 47 | 42 | 23 | 34 | 38 | 46 | 24 | 2 | 9 | 50 | 60 | 58 | 30 | 30 | 35 | 45 | 26 | 43 | 47 | 60 |

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| DAYS. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MONTHS. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| January.... Min. | 58 | 41 | 34 | 12 | 6 | 27 | 10 | 15 | 33 | 35 | 5 | 10 | —1 | —4 | 9 | 23 | 31 | 30 | 34 | 34 | 24 | 6 | 16 | 16 | —2 | 8 | —5 | 8 | 33 | 4 | —10 |
| Max. | 2 | 57 | 51 | 20 | 2 | 37 | 34 | 38 | 40 | 43 | 27 | 26 | 25 | 24 | 33 | 50 | 38 | 40 | 56 | 42 | 32 | 22 | 25 | 37 | 24 | 28 | 34 | 40 | 43 | 14 | 40 |
| February.... Min. | 8 | 12 | —18 | 9 | —11 | —19 | 38 | 28 | 21 | 30 | 19 | 31 | 21 | 20 | 20 | 29 | 20 | 19 | 7 | 27 | 11 | 20 | —11 | —12 | —3 | 8 | —1 | 17 | 29 | | |
| Max. | 30 | 18 | 16 | 32 | 31 | 35 | 56 | 54 | 51 | 55 | 37 | 50 | 55 | 24 | 43 | 37 | 37 | 39 | 41 | 33 | 28 | 44 | 11 | 4 | 23 | 28 | 35 | 26 | 41 | | |
| March ..... Min. | 2 | 13 | 10 | 6 | 4 | 37 | 38 | 40 | 31 | 26 | 26 | 27 | 31 | 8 | 5 | 12 | 24 | 14 | 0 | 2 | 23 | 23 | 21 | 16 | 22 | 39 | 34 | 30 | 33 | 25 | 28 |
| Max. | 35 | 42 | 34 | 46 | 56 | 64 | 73 | 56 | 48 | 48 | 42 | 35 | 36 | 28 | 27 | 42 | 32 | 24 | 20 | 42 | 56 | 38 | 43 | 48 | 34 | 61 | 44 | 50 | 55 | 45 | 45 |
| April..... Min. | 32 | 25 | 26 | 33 | 28 | 28 | 28 | 28 | 21 | 29 | 32 | 29 | 30 | 42 | 47 | 36 | 35 | 28 | 32 | 40 | 34 | 40 | 29 | 34 | 32 | 29 | 30 | 34 | 41 | 26 | |
| Max. | 42 | 53 | 46 | 40 | 44 | 50 | 60 | 46 | 43 | 53 | 56 | 57 | 60 | 72 | 57 | 58 | 51 | 49 | 60 | 58 | 60 | 53 | 65 | 54 | 57 | 69 | 52 | 64 | 53 | 49 | |
| May..... Min. | 28 | 39 | 43 | 38 | 42 | 43 | 48 | 53 | 53 | 53 | 53 | 38 | 36 | 45 | 36 | 32 | 35 | 48 | 54 | 43 | 56 | 63 | 40 | 36 | 48 | 39 | 41 | 60 | 61 | 45 | 40 |
| Max. | 46 | 67 | 56 | 64 | 52 | 52 | 80 | 78 | 60 | 70 | 58 | 53 | 62 | 62 | 56 | 72 | 72 | 70 | 74 | 78 | 80 | 83 | 60 | 76 | 78 | 73 | 87 | 87 | 86 | 87 | 73 |
| June..... Min. | 43 | 41 | 60 | 64 | 52 | 58 | 50 | 48 | 58 | 66 | 64 | 61 | 61 | 65 | 66 | 69 | 65 | 70 | 69 | 68 | 62 | 55 | 50 | 56 | 68 | 61 | 62 | 68 | 67 | 63 | |
| Max. | 80 | 82 | 66 | 74 | 70 | 68 | 72 | 74 | 88 | 83 | 75 | 88 | 76 | 80 | 86 | 86 | 85 | 84 | 84 | 80 | 78 | 75 | 80 | 87 | 84 | 85 | 87 | 87 | 84 | 84 | |
| July..... Min. | 64 | 66 | 74 | 68 | 70 | 78 | 60 | 63 | 74 | 68 | 72 | 74 | 71 | 72 | 67 | 63 | 73 | 76 | 67 | 74 | 55 | 60 | 55 | 58 | 52 | 52 | 46 | 62 | 67 | 57 | 62 |
| Max. | 83 | 9- | 90 | 93 | 84 | 82 | 83 | 93 | 87 | 93 | 92 | 92 | 94 | 91 | 89 | 91 | 94 | 96 | 94 | 84 | 76 | 65 | 72 | 74 | 72 | 70 | 76 | 85 | 79 | 74 | 78 |
| August..... Min. | 61 | 59 | 56 | 62 | 67 | 73 | 73 | 73 | 61 | 60 | 60 | 60 | 68 | 66 | 73 | 66 | 64 | 61 | 64 | 55 | 50 | 50 | 56 | 53 | 63 | 68 | 55 | 50 | 48 | 45 | 48 |
| Max. | 83 | 83 | 83 | 85 | 90 | 94 | 97 | 89 | 87 | 92 | 90 | 89 | 90 | 90 | 91 | 84 | 78 | 77 | 78 | 65 | 70 | 74 | 76 | 79 | 85 | 78 | 67 | 72 | 76 | 80 | 87 |
| September .. Min. | 58 | 65 | 52 | 53 | 52 | 48 | 45 | 56 | 55 | 43 | 48 | 43 | 47 | 50 | 58 | 51 | 47 | 50 | 57 | 57 | 55 | 48 | 42 | 49 | 48 | 50 | 46 | 46 | 45 | 50 | |
| Max. | 98 | 74 | 75 | 75 | 65 | 72 | 75 | 62 | 57 | 71 | 71 | 75 | 73 | 73 | 77 | 69 | 58 | 64 | 63 | 61 | 57 | 73 | 73 | 62 | 75 | 55 | 55 | 65 | 70 | 60 | |
| October ..... Min. | 47 | 40 | 30 | 44 | 48 | 41 | 46 | 35 | 32 | 28 | 36 | 26 | 28 | 34 | 31 | 30 | 42 | 37 | 29 | 28 | 36 | 38 | 55 | 56 | 36 | 34 | 34 | 28 | 26 | 24 | 22 |
| Max. | 61 | 60 | 68 | 65 | 56 | 51 | 57 | 55 | 53 | 66 | 50 | 58 | 63 | 56 | 37 | 50 | 49 | 59 | 69 | 69 | 62 | 59 | 68 | 68 | 57 | 51 | 57 | 54 | 55 | 65 | 61 |
| November... Min. | 38 | 45 | 48 | 38 | 31 | 21 | 38 | 42 | 45 | 33 | 42 | 42 | 40 | 35 | 32 | 30 | 24 | 22 | 37 | 34 | 36 | 34 | 35 | 35 | 31 | 26 | 18 | 24 | 25 | 21 | |
| Max. | 61 | 80 | 64 | 64 | 56 | 63 | 44 | 55 | 55 | 49 | 48 | 47 | 55 | 50 | 47 | 56 | 53 | 53 | 42 | 39 | 42 | 40 | 43 | 51 | 48 | 45 | 48 | 45 | 47 | 33 | |
| December... Min. | 6 | —1 | 25 | 16 | 18 | 10 | 22 | 24 | 24 | —8 | —11 | 4 | 14 | 29 | 17 | 8 | —20 | —10 | —8 | —8 | —10 | 7 | 14 | —1 | —2 | 9 | 19 | —5 | —1 | 16 | 18 |
| Max. | 17 | 27 | 44 | 32 | 45 | 50 | 50 | 43 | 24 | 10 | 22 | 29 | 44 | 41 | 33 | 32 | 10 | 20 | 28 | 10 | 12 | 20 | 34 | 20 | 39 | 32 | 34 | 32 | 29 | 32 | 30 |

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| Days. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Months. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| January.....Min. | 6 | 14 | 3 | −5 | −2 | −11 | 10 | 24 | −3 | −14 | −6 | −4 | −2 | −5 | −10 | 8 | −7 | −18 | −11 | −32 | 11 | 9 | 11 | −15 | −4 | −29 | 0 | −2 | 15 | 11 | −1 |
| Max. | 29 | 18 | 26 | 18 | 29 | 28 | 37 | 55 | 27 | 21 | 29 | 21 | 27 | 32 | 13 | 34 | 23 | 42 | 27 | 27 | 35 | 30 | 20 | 13 | 44 | 36 | 29 | 50 | 56 | 51 | 42 |
| February...Min. | 30 | 37 | 37 | 53 | 13 | 22 | 17 | 25 | 1 | 1 | 8 | 23 | 6 | 8 | 3 | 28 | 28 | 11 | 3 | 8 | 14 | 12 | 18 | 28 | 32 | 26 | 16 | 8 | | | |
| Max. | 50 | 52 | 62 | 53 | 61 | 50 | 43 | 43 | 41 | 49 | 54 | 55 | 24 | 42 | 45 | 55 | 32 | 37 | 30 | 34 | 51 | 55 | 57 | 37 | 41 | 45 | 50 | 65 | | | |
| March.....Min. | 20 | 16 | 30 | 32 | 17 | 17 | 13 | 14 | 29 | 17 | 9 | 28 | 38 | 12 | 27 | 16 | 22 | 14 | 6 | 5 | 20 | 33 | 35 | 28 | 30 | 32 | 40 | 42 | 32 | 25 | 30 |
| Max. | 64 | 42 | 54 | 50 | 35 | 36 | 44 | 37 | 53 | 33 | 40 | 38 | 38 | 45 | 40 | 36 | 32 | 34 | 32 | 45 | 34 | 54 | 62 | 52 | 48 | 36 | 52 | 52 | 40 | 52 | 62 |
| April.....Min. | 38 | 36 | 36 | 26 | 31 | 34 | 37 | 39 | 36 | 34 | 35 | 31 | 26 | 28 | 26 | 28 | 36 | 41 | 39 | 40 | 39 | 42 | 36 | 38 | 44 | 43 | 36 | 39 | 39 | 42 | |
| Max. | 50 | 46 | 54 | 60 | 38 | 48 | 54 | 62 | 66 | 67 | 63 | 52 | 64 | 65 | 70 | 68 | 48 | 58 | 43 | 54 | 49 | 72 | 83 | 82 | 74 | 68 | 73 | 62 | 49 | 63 | |
| May.....Min. | 46 | 41 | 36 | 37 | 27 | 35 | 35 | 33 | 42 | 39 | 42 | 37 | 38 | 44 | 53 | 54 | 50 | 52 | 70 | 62 | 54 | 56 | 42 | 48 | 44 | 46 | 49 | 41 | 50 | 53 | 53 |
| Max. | 65 | 49 | 56 | 55 | 67 | 67 | 66 | 68 | 50 | 47 | 67 | 72 | 78 | 78 | 81 | 85 | 80 | 80 | 85 | 78 | 73 | 60 | 67 | 54 | 58 | 60 | 65 | 79 | 80 | 83 | 86 |
| June.....Min. | 61 | 62 | 63 | 68 | 56 | 60 | 58 | 59 | 61 | 65 | 52 | 51 | 56 | 63 | 60 | 68 | 66 | 52 | 64 | 55 | 48 | 64 | 47 | 57 | 64 | 61 | 60 | 54 | 58 | 54 | |
| Max. | 86 | 88 | 85 | 78 | 70 | 62 | 64 | 69 | 73 | 79 | 72 | 73 | 82 | 84 | 84 | 80 | 78 | 82 | 88 | 75 | 73 | 68 | 71 | 80 | 87 | 67 | 72 | 78 | 79 | 73 | |
| July.....Min. | 60 | 65 | 56 | 62 | 53 | 63 | 58 | 56 | 67 | 66 | 60 | 57 | 57 | 58 | 53 | 64 | 68 | 65 | 73 | 72 | 70 | 64 | 65 | 62 | 66 | 63 | 63 | 68 | 67 | 70 | 71 |
| Max. | 80 | 73 | 80 | 80 | 83 | 71 | 78 | 80 | 82 | 82 | 80 | 80 | 77 | 78 | 81 | 85 | 78 | 85 | 78 | 82 | 82 | 84 | 82 | 82 | 90 | 89 | 67 | 69 | 79 | 76 | 79 |
| August.....Min. | 64 | 65 | 63 | 64 | 57 | 59 | 63 | 63 | 65 | 64 | 63 | 58 | 68 | 70 | 70 | 67 | 65 | 64 | 60 | 62 | 62 | 58 | 61 | 66 | 70 | 68 | 64 | 63 | 67 | 64 | 51 |
| Max. | 80 | 76 | 82 | 76 | 78 | 77 | 85 | 85 | 67 | 79 | 80 | 85 | 82 | 81 | 76 | 81 | 82 | 81 | 82 | 84 | 82 | 83 | 87 | 86 | 75 | 76 | 82 | 87 | 81 | 77 | 81 |
| September..Min. | 66 | 58 | 54 | 53 | 54 | 60 | 53 | 51 | 47 | 48 | 55 | 56 | 65 | 62 | 61 | 67 | 67 | 57 | 42 | 46 | 48 | 44 | 37 | 44 | 48 | 58 | 58 | 55 | 55 | 42 | |
| Max. | 74 | 73 | 65 | 73 | 80 | 67 | 63 | 66 | 76 | 78 | 80 | 86 | 87 | 83 | 87 | 83 | 86 | 69 | 70 | 75 | 63 | 63 | 78 | 83 | 85 | 85 | 75 | 65 | 72 | 75 | |
| October.....Min. | 48 | 52 | 58 | 54 | 52 | 32 | 30 | 33 | 40 | 57 | 42 | 47 | 43 | 34 | 47 | 52 | 40 | 38 | 40 | 44 | 42 | 36 | 28 | 47 | 44 | 32 | 26 | 28 | 35 | 36 | 35 |
| Max. | 84 | 81 | 65 | 63 | 60 | 58 | 62 | 62 | 56 | 69 | 56 | 58 | 63 | 54 | 65 | 63 | 62 | 69 | 52 | 46 | 46 | 42 | 61 | 61 | 67 | 45 | 58 | 65 | 70 | 62 | 48 |
| November...Min. | 29 | 30 | 32 | 32 | 33 | 28 | 22 | 24 | 50 | 32 | 31 | 26 | 28 | 20 | 32 | 52 | 30 | 40 | 30 | 24 | 11 | 18 | 29 | 31 | 33 | 42 | 54 | 46 | 32 | 28 | |
| Max. | 55 | 50 | 58 | 52 | 52 | 53 | 63 | 51 | 69 | 50 | 53 | 48 | 41 | 58 | 68 | 69 | 58 | 46 | 36 | 42 | 44 | 44 | 49 | 43 | 43 | 59 | 60 | 56 | 38 | 42 | |
| December...Min. | 25 | 7 | 3 | 18 | 33 | 42 | 20 | 25 | 25 | 15 | 25 | 26 | 22 | 22 | 14 | 37 | 27 | 21 | 20 | 32 | 19 | 30 | 22 | 19 | 18 | 19 | 19 | 19 | 18 | 23 | 21 |
| Max. | 38 | 32 | 35 | 37 | 37 | 44 | 40 | 43 | 40 | 30 | 39 | 44 | 44 | 40 | 40 | 55 | 57 | 47 | 42 | 54 | 43 | 52 | 52 | 52 | 52 | 52 | 55 | 55 | 58 | 40 | 39 |

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| DAYS. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MONTHS. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| January.....Min. | 19 | 21 | —10 | —10 | 21 | —4 | —24 | —35 | 2 | 8 | 31 | 33 | 30 | 28 | 29 | 4 | —2 | 12 | 8 | 20 | 35 | 34 | 33 | —3 | 14 | 27 | 30 | 32 | —2 | —3 | 2 |
| Max. | 41 | 33 | 34 | 24 | 35 | 28 | 14 | 4 | 37 | 35 | 40 | 53 | 50 | 49 | 42 | 40 | 39 | 45 | 50 | 40 | 42 | 54 | 35 | 19 | 50 | 38 | 52 | 40 | 30 | 30 | 20 |
| February....Min. | 18 | —2 | —15 | —2 | —2 | 3 | 15 | 14 | 37 | 20 | 17 | 3 | 6 | —2 | —8 | 15 | 12 | 14 | 5 | 0 | 26 | 27 | 28 | 33 | 31 | 25 | 32 | 27 | | | |
| Max. | 22 | 40 | 45 | 52 | 50 | 50 | 64 | 45 | 48 | 26 | 33 | 43 | 42 | 42 | 42 | 49 | 38 | 33 | 41 | 29 | 35 | 29 | 45 | 52 | 36 | 48 | 58 | 59 | | | |
| March.....Min. | 17 | 12 | 34 | 30 | 20 | 20 | 34 | 38 | 32 | 28 | 34 | 32 | 31 | 32 | 28 | 24 | 30 | 33 | 30 | 34 | 17 | 16 | 25 | 36 | 6 | 6 | 21 | 35 | 36 | 31 | 31 |
| Max. | 44 | 50 | 38 | 42 | 46 | 55 | 51 | 67 | 65 | 72 | 41 | 37 | 38 | 49 | 53 | 58 | 46 | 44 | 48 | 42 | 41 | 46 | 50 | 56 | 30 | 50 | 47 | 43 | 49 | 65 | 60 |
| April.....Min. | 36 | 32 | 34 | 32 | 33 | 32 | 36 | 38 | 42 | 38 | 43 | 42 | 43 | 41 | 36 | 44 | 42 | 34 | 36 | 37 | 48 | 43 | 48 | 43 | 48 | 56 | 52 | 50 | 46 | 48 | |
| Max. | 56 | 53 | 69 | 63 | 46 | 49 | 50 | 66 | 65 | 54 | 53 | 50 | 58 | 60 | 67 | 64 | 60 | 73 | 79 | 72 | 67 | 70 | 52 | 56 | 78 | 65 | 60 | 58 | 59 | 52 | |
| May.....Min. | 45 | 44 | 51 | 60 | 59 | 44 | 39 | 42 | 54 | 54 | 43 | 38 | 35 | 40 | 32 | 36 | 34 | 42 | 40 | 45 | 44 | 46 | 45 | 46 | 50 | 48 | 48 | 48 | 48 | 48 | 52 |
| Max. | 66 | 81 | 90 | 84 | 72 | 70 | 79 | 81 | 67 | 67 | 54 | 50 | 58 | 53 | 54 | 62 | 68 | 72 | 71 | 53 | 62 | 54 | 70 | 68 | 77 | 77 | 74 | 72 | 72 | 65 | 68 |
| June.....Min. | 44 | 42 | 60 | 58 | 64 | 47 | 38 | 47 | 52 | 44 | 48 | 45 | 44 | 48 | 48 | 56 | 52 | 57 | 52 | 50 | 54 | 54 | 60 | 58 | 62 | 52 | 48 | 61 | 62 | 62 | |
| Max. | 70 | 76 | 78 | 82 | 79 | 62 | 68 | 62 | 64 | 56 | 60 | 68 | 68 | 76 | 81 | 82 | 78 | 73 | 77 | 81 | 82 | 72 | 80 | 76 | 80 | 75 | 86 | 85 | 90 | 94 | |
| July.....Min. | 66 | 67 | 70 | 72 | 65 | 54 | 49 | 62 | 74 | 66 | 62 | 64 | 80 | 59 | 62 | 54 | 63 | 72 | 73 | 63 | 66 | 65 | 58 | 56 | 55 | 67 | 67 | 58 | 52 | 60 | 58 |
| Max. | 95 | 96 | 100 | 86 | 88 | 80 | 85 | 94 | 90 | 90 | 83 | 80 | 46 | 87 | 78 | 78 | 80 | 92 | 93 | 90 | 80 | 80 | 80 | 86 | 87 | 80 | 86 | 78 | 82 | 78 | 68 |
| August.....Min. | 57 | 58 | 62 | 58 | 60 | 66 | 63 | 57 | 62 | 63 | 60 | 55 | 56 | 57 | 56 | 66 | 69 | 64 | 55 | 61 | 65 | 62 | 50 | 48 | 60 | 46 | 48 | 52 | 58 | 57 | 55 |
| Max. | 63 | 81 | 83 | 86 | 89 | 74 | 80 | 80 | 70 | 78 | 80 | 78 | 82 | 85 | 77 | 84 | 83 | 80 | 79 | 78 | 77 | 76 | 78 | 78 | 72 | 74 | 80 | 78 | 83 | 80 | 85 |
| September..Min | 66 | 65 | 64 | 62 | 58 | 61 | 59 | 52 | 46 | 56 | 63 | 64 | 68 | 57 | 53 | 39 | 44 | 51 | 50 | 55 | 62 | 51 | 34 | 36 | 53 | 46 | 45 | 35 | 32 | 35 | |
| Max. | 89 | 88 | 82 | 65 | 68 | 80 | 65 | 72 | 72 | 76 | 78 | 75 | 83 | 71 | 64 | 69 | 74 | 83 | 76 | 85 | 78 | 65 | 66 | 65 | 75 | 78 | 70 | 63 | 66 | 72 | |
| October.....Min. | 42 | 46 | 54 | 46 | 41 | 44 | 34 | 46 | 42 | 48 | 34 | 42 | 44 | 43 | 41 | 47 | 46 | 57 | 57 | 38 | 45 | 36 | 44 | 52 | 42 | 36 | 46 | 42 | 27 | 31 | 41 |
| Max. | 74 | 80 | 80 | 75 | 74 | 55 | 65 | 68 | 72 | 62 | 62 | 48 | 67 | 74 | 75 | 84 | 80 | 78 | 59 | 59 | 79 | 78 | 60 | 62 | 73 | 71 | 63 | 55 | 61 | 47 | 57 |
| November...Min. | 38 | 34 | 38 | 22 | 20 | 23 | 14 | 26 | 28 | 33 | 32 | 40 | 32 | 29 | 22 | 20 | 36 | 36 | 34 | 38 | 33 | 35 | 40 | 37 | 30 | 33 | 22 | 33 | 34 | 34 | |
| Max. | 48 | 61 | 50 | 44 | 40 | 43 | 44 | 37 | 37 | 43 | 55 | 58 | 53 | 49 | 52 | 52 | 48 | 42 | 54 | 43 | 48 | 43 | 46 | 43 | 38 | 47 | 42 | 44 | 44 | 48 | |
| December...Min. | 23 | 32 | 43 | 33 | 28 | 22 | 16 | 16 | 16 | 33 | 37 | 32 | 28 | 22 | 24 | 17 | 10 | 20 | 20 | 11 | 13 | 35 | 23 | 10 | 10 | 21 | 15 | 17 | 8 | 10 | 5 |
| Max. | 43 | 58 | 48 | 35 | 37 | 38 | 33 | 36 | 26 | 55 | 44 | 42 | 36 | 42 | 32 | 24 | 41 | 37 | 32 | 32 | 25 | 40 | 33 | 27 | 37 | 35 | 30 | 33 | 30 | 37 | 30 |

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| DAYS. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MONTHS. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| January....Min. | 5 | 10 | 8 | 10 | 19 | 13 | 6 | 10 | 29 | 15 | —2 | —8 | —7 | 16 | 2 | 0 | —10 | 15 | 8 | 10 | 4 | 14 | 25 | 12 | 26 | —2 | 2 | 26 | 28 | 0 | 12 |
| Max. | 29 | 24 | 25 | 30 | 35 | 30 | 36 | 37 | 38 | 30 | 25 | 25 | 28 | 39 | 4 | 14 | 24 | 40 | 32 | 23 | 18 | 40 | 34 | 40 | 45 | 6 | 27 | 49 | 31 | 29 | 39 |
| February....Min. | 14 | 16 | 6 | 20 | 24 | 22 | 24 | 12 | 14 | —3 | 3 | 12 | 38 | 18 | 3 | —1 | 12 | 14 | 6 | 10 | 10 | 5 | 4 | 13 | —2 | 16 | 20 | —1 | | | |
| Max. | 23 | 24 | 34 | 32 | 38 | 37 | 34 | 27 | 34 | 23 | 45 | 48 | 27 | 19 | 19 | 32 | 32 | 26 | 24 | 23 | 18 | 26 | 42 | 24 | 25 | 38 | 24 | 17 | | | |
| March.....Min. | 4 | 14 | 28 | 16 | 32 | 6 | 8 | 7 | 20 | 32 | 24 | 30 | 24 | 24 | 28 | 16 | 22 | 18 | 0 | 5 | 22 | 16 | 26 | 18 | 30 | 26 | 30 | 30 | 32 | 32 | 28 |
| Max. | 31 | 33 | 38 | 44 | 43 | 26 | 32 | 33 | 34 | 52 | 56 | 37 | 43 | 41 | 39 | 34 | 32 | 35 | 38 | 39 | 37 | 38 | 46 | 46 | 53 | 47 | 39 | 47 | 52 | 48 | 34 |
| April.....Min. | 22 | 26 | 20 | 14 | 17 | 20 | 28 | 28 | 24 | 32 | 26 | 24 | 24 | 33 | 25 | 32 | 30 | 31 | 29 | 23 | 27 | 33 | 34 | 28 | 34 | 36 | 30 | 43 | 52 | 50 | |
| Max. | 40 | 45 | 44 | 27 | 35 | 44 | 53 | 53 | 58 | 46 | 40 | 46 | 52 | 57 | 53 | 60 | 54 | 49 | 41 | 53 | 62 | 63 | 62 | 62 | 55 | 56 | 70 | 70 | 70 | 65 | |
| May.....Min. | 42 | 34 | 34 | 30 | 30 | 48 | 45 | 44 | 37 | 37 | 45 | 45 | 62 | 60 | 58 | 63 | 62 | 58 | 62 | 63 | 64 | 46 | 40 | 35 | 29 | 48 | 35 | 50 | 52 | 55 | 62 |
| Max. | 57 | 57 | 57 | 72 | 80 | 72 | 67 | 72 | 75 | 75 | 81 | 85 | 93 | 90 | 82 | 83 | 78 | 72 | 68 | 73 | 81 | 64 | 60 | 68 | 73 | 58 | 70 | 76 | 80 | 81 | 90 |
| June.....Min. | 67 | 67 | 55 | 50 | 52 | 54 | 44 | 40 | 43 | 54 | 56 | 55 | 60 | 48 | 59 | 50 | 48 | 48 | 43 | 45 | 53 | 56 | 56 | 56 | 61 | 65 | 63 | 67 | 70 | 59 | |
| Max. | 94 | 80 | 58 | 67 | 76 | 72 | 58 | 68 | 72 | 74 | 74 | 68 | 75 | 78 | 59 | 54 | 63 | 66 | 69 | 76 | 81 | 72 | 81 | 84 | 81 | 82 | 90 | 88 | 80 | 76 | |
| July.....Min. | 51 | 52 | 62 | 71 | 61 | 50 | 56 | 59 | 59 | 61 | 61 | 65 | 58 | 63 | 69 | 68 | 66 | 54 | 51 | 51 | 58 | 62 | 67 | 62 | 50 | 58 | 57 | 60 | 63 | 63 | 62 |
| Max. | 77 | 85 | 91 | 93 | 81 | 80 | 67 | 78 | 81 | 81 | 81 | 81 | 86 | 90 | 90 | 87 | 77 | 74 | 72 | 76 | 79 | 82 | 75 | 78 | 77 | 69 | 83 | 85 | 86 | 86 | 87 |
| August.....Min. | 61 | 64 | 69 | 64 | 65 | 70 | 54 | 57 | 59 | 49 | 45 | 50 | 55 | 64 | 57 | 53 | 53 | 55 | 57 | 49 | 52 | 64 | 69 | 59 | 56 | 58 | 58 | 51 | 51 | 58 | 51 |
| Max. | 90 | 91 | 90 | 83 | 85 | 85 | 82 | 69 | 71 | 72 | 75 | 82 | 86 | 86 | 70 | 60 | 57 | 62 | 72 | 76 | 81 | 88 | 88 | 81 | 76 | 71 | 69 | 72 | 78 | 75 | 79 |
| September...Min. | 55 | 67 | 61 | 60 | 57 | 47 | 51 | 63 | 50 | 51 | 46 | 46 | 48 | 51 | 49 | 54 | 54 | 47 | 56 | 44 | 37 | 46 | 43 | 45 | 39 | 30 | 33 | 39 | 51 | 50 | |
| Max. | 88 | 86 | 85 | 67 | 72 | 74 | 78 | 76 | 70 | 69 | 69 | 71 | 67 | 66 | 69 | 66 | 71 | 71 | 69 | 63 | 63 | 62 | 69 | 69 | 57 | 62 | 66 | 65 | 75 | 82 | |
| October.....Min. | 54 | 55 | 54 | 52 | 39 | 50 | 48 | 52 | 58 | 60 | 50 | 51 | 54 | 43 | 42 | 47 | 60 | 55 | 57 | 34 | 30 | 32 | 52 | 38 | 26 | 21 | 27 | 27 | 44 | 36 | 36 |
| Max. | 87 | 85 | 82 | 76 | 80 | 70 | 83 | 87 | 83 | 76 | 55 | 72 | 80 | 76 | 88 | 92 | 66 | 68 | 57 | 58 | 76 | 62 | 80 | 56 | 42 | 65 | 64 | 56 | 58 | 58 | 50 |
| November...Min. | 30 | 22 | 30 | 20 | 1 | 9 | 28 | 24 | 36 | 54 | 39 | 42 | 40 | 40 | 44 | 22 | 39 | 36 | 26 | 28 | 13 | 7 | 23 | 22 | 20 | 30 | 26 | 33 | 52 | 18 | |
| Max | 46 | 43 | 32 | 32 | 40 | 29 | 55 | 55 | 62 | 66 | 56 | 64 | 64 | 51 | 72 | 68 | 58 | 37 | 36 | 34 | 20 | 41 | 48 | 42 | 53 | 50 | 33 | 58 | 52 | 26 | |
| December....Min. | 15 | 32 | 36 | 36 | 26 | 33 | 44 | 35 | 29 | 28 | 28 | 34 | 21 | 23 | 28 | 30 | 23 | 7 | 10 | 21 | —4 | —2 | 7 | 20 | 29 | —1 | —1 | 14 | 23 | 32 | 0 |
| Max. | 40 | 60 | 53 | 58 | 38 | 39 | 58 | 48 | 52 | 38 | 50 | 46 | 38 | 34 | 48 | 39 | 43 | 32 | 37 | 33 | 6 | 13 | 39 | 30 | 31 | 25 | 23 | 37 | 42 | 41 | 10 |

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| DAYS. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MONTHS. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| January.....Min. | 22 | 10 | 19 | 22 | 24 | 17 | 27 | 10 | 14 | 32 | 16 | 33 | 20 | —7 | 2 | 9 | 28 | 31 | 34 | 28 | 23 | 2 | 32 | 28 | 14 | 14 | 19 | 36 | 20 | 2 | 40 |
| Max. | 43 | 56 | 43 | 49 | 42 | 25 | 57 | 50 | 35 | 52 | 52 | 40 | 25 | 37 | 28 | 30 | 41 | 38 | 51 | 37 | 34 | 30 | 51 | 42 | 52 | 56 | 37 | 62 | 34 | 40 | 48 |
| February....Min. | 22 | —8 | 1 | 15 | 2 | 9 | 4 | 5 | 20 | —10 | 2 | 20 | 39 | 37 | 26 | 27 | 17 | 33 | 26 | 11 | 19 | 24 | 29 | 13 | 10 | 34 | 28 | 27 | 41 | | |
| Max. | 33 | 24 | 19 | 35 | 38 | 39 | 25 | 30 | 30 | 23 | 47 | 48 | 49 | 46 | 30 | 48 | 58 | 60 | 28 | 34 | 34 | 53 | 38 | 43 | 41 | 42 | 68 | 48 | 62 | | |
| March .....Min. | 32 | 24 | 20 | 36 | 34 | 30 | 26 | 26 | 11 | 18 | 13 | 11 | 14 | 23 | 24 | 28 | 26 | 7 | 17 | 24 | 30 | 26 | 27 | 33 | 8 | 17 | 20 | 30 | 20 | 25 | 27 |
| Max. | 44 | 42 | 52 | 61 | 67 | 38 | 38 | 34 | 21 | 42 | 21 | 34 | 38 | 33 | 50 | 37 | 37 | 45 | 42 | 43 | 50 | 47 | 54 | 33 | 33 | 42 | 44 | 39 | 41 | 54 | 46 |
| April.....Min. | 30 | 28 | 38 | 50 | 53 | 34 | 28 | 22 | 25 | 36 | 38 | 22 | 30 | 40 | 35 | 50 | 35 | 33 | 37 | 41 | 33 | 36 | 33 | 36 | 28 | 42 | 48 | 33 | 37 | 50 | |
| Max. | 68 | 70 | 48 | 73 | 61 | 60 | 47 | 42 | 52 | 68 | 45 | 40 | 65 | 62 | 30 | 68 | 40 | 57 | 55 | 59 | 73 | 75 | 62 | 60 | 70 | 68 | 65 | 61 | 68 | 65 | |
| May.....Min. | 30 | 40 | 42 | 58 | 55 | 48 | 49 | 49 | 52 | 65 | 54 | 40 | 42 | 32 | 42 | 45 | 48 | 44 | 56 | 59 | 61 | 64 | 58 | 63 | 65 | 64 | 71 | 49 | 52 | 51 | 46 |
| Max. | 55 | 64 | 85 | 89 | 85 | 78 | 76 | 74 | 94 | 95 | 86 | 74 | 61 | 58 | 68 | 66 | 83 | 54 | 66 | 87 | 91 | 81 | 82 | 87 | 92 | 94 | 93 | 81 | 73 | 63 | 78 |
| June.....Min. | 56 | 51 | 46 | 46 | 44 | 56 | 56 | 50 | 50 | 50 | 55 | 66 | 56 | 57 | 53 | 48 | 50 | 48 | 52 | 55 | 55 | 51 | 51 | 58 | 62 | 67 | 61 | 62 | 72 | 62 | |
| Max. | 79 | 67 | 71 | 71 | 69 | 68 | 64 | 66 | 66 | 78 | 85 | 81 | 80 | 72 | 73 | 80 | 79 | 83 | 88 | 86 | 78 | 70 | 76 | 90 | 94 | 87 | 88 | 88 | 88 | 81 | |
| July.....Min. | 62 | 66 | 61 | 67 | 56 | 56 | 58 | 56 | 70 | 74 | 70 | 56 | 63 | 57 | 53 | 66 | 59 | 57 | 57 | 57 | 68 | 59 | 59 | 62 | 56 | 59 | 64 | 67 | 52 | 48 | 52 |
| Max. | 85 | 73 | 71 | 83 | 86 | 85 | 86 | 86 | 92 | 97 | 82 | 78 | 78 | 62 | 77 | 80 | 85 | 84 | 85 | 75 | 80 | 77 | 74 | 84 | 85 | 89 | 90 | 73 | 60 | 76 | 85 |
| August.....Min. | 59 | 66 | 68 | 61 | 60 | 48 | 51 | 51 | 58 | 59 | 67 | 60 | 53 | 53 | 52 | 42 | 42 | 48 | 55 | 56 | 67 | 57 | 57 | 63 | 64 | 42 | 42 | 56 | 71 | 59 | 46 |
| Max. | 91 | 92 | 68 | 66 | 75 | 78 | 85 | 84 | 87 | 86 | 87 | 81 | 83 | 79 | 69 | 73 | 77 | 79 | 75 | 82 | 80 | 84 | 92 | 91 | 70 | 71 | 73 | 91 | 83 | 70 | 77 |
| September...Min. | 52 | 60 | 60 | 69 | 68 | 58 | 64 | 54 | 58 | 41 | 46 | 57 | 50 | 54 | 52 | 50 | 48 | 52 | 51 | 60 | 60 | 52 | 38 | 34 | 44 | 51 | 60 | 62 | 44 | 40 | |
| Max. | 79 | 79 | 91 | 93 | 90 | 90 | 76 | 63 | 69 | 56 | 77 | 77 | 76 | 66 | 65 | 67 | 76 | 68 | 72 | 68 | 74 | 65 | 63 | 70 | 78 | 77 | 76 | 74 | 78 | 64 | |
| October.....Min. | 37 | 41 | 41 | 48 | 49 | 38 | 46 | 30 | 36 | 38 | 45 | 46 | 38 | 36 | 32 | 38 | 58 | 38 | 30 | 30 | 27 | 47 | 47 | 38 | 32 | 32 | 42 | 32 | 26 | 42 | 50 |
| Max. | 63 | 70 | 72 | 76 | 65 | 66 | 62 | 65 | 74 | 75 | 74 | 73 | 58 | 72 | 72 | 69 | 72 | 55 | 53 | 58 | 64 | 56 | 65 | 42 | 52 | 48 | 47 | 58 | 51 | 49 | 58 |
| November....Min. | 30 | 32 | 22 | 30 | 44 | 51 | 48 | 39 | 28 | 34 | 38 | 37 | 36 | 26 | 22 | 22 | 22 | 28 | 22 | 17 | 18 | 10 | 8 | 10 | 22 | 10 | 4 | 9 | 25 | 18 | |
| Max. | 56 | 58 | 58 | 55 | 53 | 59 | 68 | 58 | 64 | 70 | 50 | 50 | 44 | 51 | 38 | 48 | 46 | 42 | 47 | 37 | 30 | 30 | 30 | 30 | 34 | 42 | 38 | 29 | 51 | | |
| December....Min. | 18 | 20 | 17 | 14 | 11 | 32 | 27 | 4 | —8 | 8 | —5 | 10 | 28 | 20 | 32 | 32 | 12 | 12 | 12 | 11 | 17 | 17 | 10 | 10 | 20 | 20 | 27 | 20 | 6 | —5 | —7 |
| Max. | 23 | 32 | 40 | 42 | 38 | 48 | 33 | 18 | 36 | 30 | 17 | 28 | 38 | 56 | 45 | 34 | 32 | 32 | 32 | 43 | 30 | 45 | 48 | 26 | 44 | 31 | 33 | 24 | 14 | 12 | 25 |

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| DAYS. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MONTHS. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| January.... Min. | —19 | —14 | —6 | —1 | 8 | 13 | 27 | 14 | —8 | 16 | 17 | 12 | 1 | 25 | 1 | 2 | 7 | 14 | 6 | 1 | 2 | 10 | 18 | 6 | —14 | 4 | 13 | 1 | —3 | —1 | —1 |
| Max. | 25 | 14 | 37 | 19 | 27 | 35 | 39 | 32 | 20 | 34 | 29 | 24 | 34 | 34 | 31 | 44 | 45 | 38 | 28 | 46 | 26 | 45 | 31 | 35 | 37 | 35 | 22 | 11 | 19 | 12 | 25 |
| February....Min. | 1 | —11 | —9 | 6 | —4 | 6 | —1 | 13 | 30 | 35 | 38 | 31 | 34 | 11 | 5 | 21 | 22 | 7 | 24 | 7 | 24 | 13 | 26 | —7 | —5 | —4 | 5 | 31 | | | |
| Max. | 13 | 7 | 21 | 34 | 39 | 50 | 50 | 42 | 50 | 45 | 55 | 38 | 36 | 30 | 40 | 44 | 40 | 28 | 44 | 37 | 32 | 49 | 38 | 13 | 28 | 38 | 50 | 42 | | | |
| March.....Min. | 26 | 25 | 34 | 32 | 32 | 28 | 21 | 23 | 27 | 35 | 22 | 22 | 32 | 33 | 26 | 28 | 27 | 31 | 33 | 31 | 33 | 33 | 31 | 26 | 25 | 27 | 30 | 27 | 27 | 32 | 32 |
| Max. | 42 | 39 | 40 | 36 | 39 | 48 | 57 | 63 | 48 | 41 | 30 | 52 | 48 | 58 | 58 | 50 | 50 | 42 | 53 | 38 | 52 | 48 | 46 | 45 | 45 | 42 | 42 | 45 | 47 | 41 | 41 |
| April.....Min. | 28 | 29 | 19 | 19 | 15 | 14 | 20 | 30 | 26 | 27 | 27 | 24 | 28 | 33 | 33 | 36 | 38 | 35 | 32 | 30 | 31 | 30 | 36 | 39 | 50 | 55 | 51 | 42 | 41 | 33 | |
| Max. | 58 | 41 | 41 | 41 | 30 | 30 | 50 | 57 | 67 | 65 | 60 | 47 | 42 | 50 | 43 | 54 | 58 | 56 | 56 | 66 | 68 | 58 | 72 | 83 | 80 | 63 | 60 | 80 | 67 | 54 | |
| May.....Min. | 28 | 46 | 36 | 30 | 31 | 44 | 42 | 50 | 46 | 61 | 53 | 65 | 52 | 45 | 52 | 45 | 44 | 45 | 48 | 49 | 51 | 50 | 52 | 49 | 53 | 52 | 54 | 62 | 57 | 57 | 60 |
| Max. | 66 | 73 | 67 | 72 | 77 | 50 | 78 | 75 | 82 | 90 | 90 | 89 | 80 | 75 | 60 | 49 | 49 | 49 | 58 | 68 | 60 | 69 | 78 | 82 | 77 | 80 | 88 | 88 | 80 | 90 | 81 |
| June.....Min. | 58 | 55 | 49 | 47 | 42 | 41 | 36 | 51 | 51 | 50 | 47 | 49 | 54 | 55 | 56 | 49 | 45 | 56 | 58 | 54 | 56 | 45 | 41 | 44 | 53 | 54 | 54 | 60 | 61 | 60 | |
| Max. | 80 | 75 | 60 | 69 | 74 | 64 | 64 | 62 | 72 | 54 | 72 | 80 | 70 | 72 | 70 | 68 | 77 | 72 | 78 | 71 | 70 | 65 | 69 | 73 | 76 | 66 | 72 | 84 | 79 | 77 | |
| July.....Min. | 60 | 50 | 51 | 60 | 54 | 63 | 60 | 65 | 61 | 64 | 64 | 58 | 66 | 70 | 54 | 57 | 57 | 52 | 51 | 53 | 61 | 62 | 61 | 55 | 61 | 63 | 61 | 63 | 62 | 62 | 62 |
| Max. | 78 | 83 | 81 | 83 | 81 | 85 | 82 | 84 | 89 | 94 | 77 | 83 | 92 | 83 | 83 | 85 | 78 | 62 | 77 | 83 | 75 | 79 | 70 | 84 | 83 | 82 | 80 | 84 | 68 | 75 | 75 |
| August.....Min. | 69 | 66 | 63 | 66 | 71 | 71 | 71 | 60 | 55 | 62 | 58 | 56 | 67 | 60 | 56 | 58 | 50 | 55 | 63 | 62 | 67 | 63 | 58 | 57 | 57 | 54 | 57 | 62 | 60 | 57 | 65 |
| Max. | 85 | 85 | 86 | 90 | 95 | 94 | 75 | 78 | 75 | 82 | 79 | 83 | 89 | 77 | 73 | 71 | 71 | 69 | 74 | 79 | 80 | 80 | 75 | 69 | 79 | 83 | 86 | 85 | 82 | 92 | 92 |
| September..Min. | 69 | 65 | 57 | 58 | 60 | 67 | 62 | 62 | 53 | 64 | 58 | 62 | 47 | 49 | 48 | 49 | 49 | 49 | 52 | 55 | 45 | 43 | 60 | 55 | 56 | 65 | 59 | 64 | 55 | 55 | |
| Max. | 90 | 67 | 65 | 66 | 69 | 75 | 96 | 76 | 76 | 67 | 66 | 72 | 76 | 74 | 70 | 67 | 74 | 76 | 77 | 75 | 75 | 67 | 79 | 66 | 85 | 87 | 80 | 85 | 68 | 77 | |
| October.....Min. | 55 | 55 | 55 | 58 | 27 | 31 | 37 | 53 | 55 | 39 | 30 | 28 | 51 | 36 | 34 | 60 | 45 | 46 | 39 | 32 | 33 | 32 | 47 | 48 | 40 | 30 | 25 | 31 | 29 | 42 | 52 |
| Max. | 85 | 66 | 77 | 66 | 42 | 61 | 72 | 80 | 72 | 62 | 56 | 58 | 76 | 55 | 70 | 70 | 55 | 59 | 53 | 61 | 44 | 69 | 62 | 52 | 58 | 40 | 55 | 67 | 48 | 61 | 62 |
| November...Min. | 47 | 48 | 49 | 37 | 30 | 44 | 30 | 40 | 45 | 39 | 28 | 25 | 32 | 38 | 28 | 30 | 32 | 46 | 39 | 30 | 21 | 24 | 8 | 24 | 15 | 18 | 31 | 7 | 13 | 37 | |
| Max. | 69 | 57 | 63 | 48 | 54 | 62 | 46 | 50 | 68 | 47 | 47 | 33 | 54 | 53 | 42 | 32 | 62 | 56 | 41 | 40 | 40 | 35 | 28 | 44 | 40 | 46 | 41 | 38 | 55 | 67 | |
| December...Min. | 33 | 29 | 25 | 30 | 30 | 27 | 35 | 28 | 25 | 19 | 7 | 13 | 25 | 55 | 23 | 5 | 5 | 17 | 27 | 22 | 27 | 22 | 40 | 12 | 16 | 23 | 38 | 38 | 38 | 39 | 24 |
| Max. | 54 | 52 | 35 | 38 | 40 | 42 | 42 | 48 | 48 | 25 | 24 | 38 | 45 | 63 | 27 | 22 | 35 | 47 | 48 | 48 | 47 | 46 | 46 | 22 | 42 | 44 | 46 | 45 | 44 | 45 | 39 |

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| Days. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Months. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| January.....Min. | 17 | 7 | 0 | —3 | —9 | —2 | 24 | 14 | 30 | 28 | 19 | 18 | 10 | 18 | 9 | 22 | 16 | —14 | 16 | —1 | 13 | 25 | —7 | —20 | —22 | 21 | 44 | 15 | 21 | 6 | 2 |
| Max. | 27 | 14 | 24 | 12 | 18 | 28 | 42 | 28 | 48 | 34 | 28 | 32 | 25 | 40 | 38 | 45 | 22 | 22 | 37 | 23 | 36 | 42 | 1 | 2 | 16 | 45 | 47 | 32 | 31 | 32 | 32 |
| February...Min | 21 | 18 | 22 | —2 | 6 | 2 | —1 | 18 | —3 | 28 | 14 | 6 | 34 | 36 | 20 | 23 | 37 | 2 | 3 | 14 | 19 | 16 | 8 | 11 | 2 | 5 | 16 | 21 | | | |
| Max. | 39 | 44 | 35 | 20 | 25 | 14 | 24 | 40 | 38 | 40 | 34 | 53 | 48 | 53 | 58 | 59 | 46 | 28 | 19 | 38 | 23 | 30 | 38 | 40 | 46 | 49 | 51 | 53 | | | |
| March.....Min. | 33 | 39 | 31 | 33 | 29 | 34 | 35 | 16 | 11 | 31 | 27 | 28 | 29 | 11 | 10 | 18 | 19 | 19 | 26 | 23 | 25 | 26 | 20 | 30 | 10 | 9 | 29 | 37 | 19 | 30 | 19 |
| Max. | 46 | 49 | 48 | 42 | 52 | 40 | 40 | 45 | 34 | 50 | 45 | 37 | 42 | 28 | 48 | 34 | 49 | 30 | 58 | 60 | 58 | 40 | 54 | 49 | 33 | 31 | 52 | 48 | 54 | 54 | 37 |
| April.....Min. | 13 | 26 | 29 | 25 | 37 | 25 | 32 | 36 | 31 | 27 | 26 | 24 | 27 | 34 | 30 | 26 | 33 | 34 | 35 | 37 | 36 | 37 | 31 | 26 | 23 | 27 | 34 | 33 | 32 | 36 | |
| Max. | 33 | 65 | 56 | 62 | 60 | 52 | 39 | 64 | 56 | 46 | 43 | 43 | 50 | 56 | 56 | 57 | 64 | 54 | 58 | 64 | 56 | 48 | 46 | 47 | 56 | 67 | 47 | 50 | 62 | 62 | |
| May.....Min. | 29 | 33 | 30 | 41 | 35 | 30 | 31 | 31 | 45 | 41 | 36 | 36 | 40 | 42 | 37 | 30 | 36 | 40 | 38 | 44 | 47 | 44 | 44 | 36 | 40 | 34 | 45 | 52 | 53 | 40 | 51 |
| Max. | 65 | 53 | 60 | 72 | 57 | 62 | 67 | 72 | 72 | 70 | 53 | 52 | 55 | 60 | 48 | 67 | 67 | 53 | 60 | 55 | 69 | 72 | 47 | 66 | 58 | 74 | 78 | 78 | 65 | 72 | 79 |
| June.....Min. | 60 | 45 | 52 | 53 | 45 | 49 | 44 | 55 | 60 | 46 | 53 | 45 | 43 | 50 | 58 | 60 | 54 | 59 | 60 | 54 | 49 | 51 | 50 | 62 | 70 | 67 | 62 | 58 | 59 | 48 | |
| Max. | 68 | 70 | 68 | 62 | 64 | 70 | 81 | 82 | 80 | 72 | 69 | 74 | 79 | 83 | 83 | 83 | 81 | 69 | 79 | 69 | 75 | 80 | 84 | 90 | 89 | 84 | 79 | 81 | 74 | 70 | |
| July.....Min. | 54 | 53 | 52 | 53 | 57 | 55 | 51 | 56 | 66 | 63 | 70 | 63 | 64 | 64 | 59 | 55 | 55 | 64 | 66 | 63 | 57 | 56 | 54 | 60 | 62 | 64 | 64 | 64 | 68 | 62 | 58 |
| Max. | 55 | 69 | 72 | 73 | 65 | 74 | 81 | 82 | 83 | 88 | 90 | 86 | 80 | 81 | 82 | 84 | 83 | 84 | 84 | 83 | 80 | 80 | 83 | 90 | 90 | 92 | 92 | 91 | 87 | 82 | 83 |
| August.....Min. | 57 | 60 | 60 | 62 | 64 | 64 | 67 | 71 | 68 | 67 | 60 | 57 | 55 | 47 | 65 | 65 | 68 | 60 | 46 | 45 | 45 | 46 | 57 | 63 | 60 | 55 | 56 | 56 | 48 | 49 | 56 |
| Max. | 83 | 87 | 92 | 93 | 90 | 93 | 93 | 89 | 89 | 86 | 80 | 85 | 85 | 96 | 92 | 80 | 88 | 72 | 71 | 77 | 77 | 82 | 84 | 83 | 81 | 70 | 78 | 82 | 83 | 88 | 88 |
| September..Min. | 67 | 63 | 65 | 67 | 63 | 62 | 55 | 54 | 61 | 44 | 52 | 53 | 39 | 50 | 50 | 50 | 46 | 48 | 57 | 64 | 56 | 53 | 53 | 55 | 54 | 55 | 46 | 49 | 48 | 50 | |
| Max. | 82 | 80 | 82 | 82 | 81 | 78 | 81 | 79 | 71 | 70 | 65 | 67 | 67 | 65 | 68 | 72 | 58 | 82 | 90 | 83 | 59 | 62 | 62 | 65 | 63 | 68 | 85 | 58 | 52 | 65 | |
| October.....Min. | 48 | 52 | 33 | 33 | 49 | 41 | 50 | 52 | 53 | 54 | 39 | 43 | 41 | 48 | 38 | 40 | 55 | 61 | 61 | 42 | 33 | 29 | 47 | 50 | 39 | 37 | 27 | 26 | 26 | 39 | 32 |
| Max. | 74 | 68 | 61 | 66 | 67 | 58 | 73 | 82 | 79 | 67 | 58 | 54 | 62 | 60 | 76 | 63 | 65 | 73 | 62 | 55 | 60 | 61 | 58 | 62 | 63 | 66 | 58 | 64 | 42 | 69 | 68 |
| November...Min. | 60 | 40 | 28 | 25 | 18 | 19 | 26 | 33 | 26 | 31 | 33 | 48 | 51 | 33 | 28 | 25 | 31 | 22 | 12 | 23 | 19 | 18 | 34 | 31 | 20 | 17 | 19 | 23 | 23 | 20 | |
| Max. | 71 | 50 | 53 | 54 | 50 | 55 | 42 | 46 | 65 | 71 | 54 | 70 | 53 | 46 | 58 | 52 | 35 | 43 | 44 | 38 | 56 | 56 | 53 | 52 | 42 | 31 | 37 | 40 | 30 | 31 | |
| December...Min. | 13 | 32 | 15 | 2 | 15 | 29 | 22 | 9 | 12 | 19 | 21 | 15 | 2 | 25 | 17 | —2 | 12 | 7 | 0 | —6 | 1 | 13 | 27 | 28 | 25 | 18 | 19 | 16 | 13 | 16 | 30 |
| Max. | 42 | 48 | 25 | 26 | 57 | 57 | 36 | 25 | 32 | 25 | 28 | 38 | 32 | 34 | 27 | 30 | 36 | 38 | 40 | 40 | 37 | 34 | 40 | 41 | 37 | 46 | 46 | 37 | 42 | 35 | 37 |

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# 1883.

| DAYS. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MONTHS. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| January....Min. | 17 | 10 | —2 | 14 | —2 | 4 | 9 | 8 | 3 | 6 | 1 | —1 | —13 | 33 | 13 | —5 | —3 | 34 | 1 | 17 | 27 | 8 | —8 | —7 | 12 | —14 | —8 | 27 | 23 | 26 | 32 |
| Max. | 40 | 36 | 36 | 24 | 8 | 10 | 27 | 26 | 21 | 13 | 25 | 23 | 33 | 37 | 35 | 22 | 15 | 40 | 23 | 27 | 44 | 12 | 12 | 15 | 35 | 35 | 18 | 36 | 31 | 50 | 37 |
| February....Min. | 16 | 6 | 11 | 22 | 15 | 0 | 19 | —6 | 12 | 3 | 4 | 20 | —8 | —7 | 14 | 18 | 33 | 21 | 0 | 3 | 22 | 12 | 20 | —11 | 20 | 25 | 4 | 4 | | | |
| Max. | 28 | 28 | 18 | 28 | 40 | 35 | 42 | 28 | 35 | 24 | 20 | 40 | 44 | 35 | 27 | 34 | 58 | 35 | 37 | 30 | 32 | 39 | 35 | 38 | 40 | 34 | 26 | 27 | | | |
| March.....Min. | —8 | 25 | 16 | —1 | —1 | —10 | 18 | —1 | —16 | 9 | 28 | 4 | 18 | —4 | 36 | 8 | —2 | 31 | 27 | 30 | 13 | 10 | 2 | 6 | 20 | 20 | 36 | 33 | 18 | 12 | 15 |
| Max. | 34 | 58 | 32 | 26 | 21 | 20 | 26 | 21 | 40 | 31 | 38 | 30 | 38 | 47 | 50 | 36 | 40 | 58 | 48 | 32 | 36 | 34 | 40 | 36 | 46 | 60 | 42 | 41 | 42 | 39 | 45 |
| April.....Min. | 14 | 14 | 15 | 18 | 30 | 35 | 30 | 28 | 24 | 35 | 35 | 35 | 40 | 32 | 31 | 34 | 48 | 39 | 35 | 43 | 34 | 32 | 35 | 31 | 28 | 27 | 36 | 39 | 32 | 26 | |
| Max. | 42 | 54 | 48 | 50 | 42 | 57 | 35 | 52 | 64 | 75 | 41 | 60 | 62 | 67 | 77 | 75 | 60 | 68 | 64 | 58 | 58 | 52 | 49 | 49 | 52 | 59 | 64 | 55 | 62 | 63 | |
| May.....Min. | 26 | 41 | 46 | 48 | 43 | 40 | 34 | 51 | 45 | 47 | 43 | 51 | 43 | 32 | 41 | 39 | 35 | 37 | 41 | 49 | 49 | 50 | 50 | 51 | 44 | 54 | 61 | 46 | 53 | 43 | 54 |
| Max. | 67 | 68 | 80 | 55 | 48 | 61 | 74 | 76 | 67 | 67 | 67 | 69 | 62 | 65 | 57 | 66 | 76 | 80 | 73 | 74 | 75 | 52 | 62 | 64 | 80 | 88 | 75 | 74 | 71 | 73 | 73 |
| June.....Min. | 46 | 42 | 42 | 63 | 61 | 55 | 65 | 64 | 55 | 64 | 68 | 63 | 64 | 53 | 47 | 52 | 52 | 59 | 67 | 66 | 57 | 64 | 57 | 58 | 65 | 57 | 61 | 63 | 66 | 63 | |
| Max. | 70 | 75 | 82 | 78 | 82 | 87 | 86 | 83 | 85 | 87 | 84 | 83 | 74 | 72 | 78 | 78 | 70 | 71 | 73 | 80 | 74 | 77 | 83 | 86 | 86 | 76 | 79 | 82 | 86 | 75 | |
| July.....Min. | 44 | 57 | 64 | 64 | 67 | 69 | 66 | 60 | 50 | 51 | 55 | 59 | 66 | 62 | 57 | 65 | 64 | 66 | 55 | 54 | 50 | 58 | 65 | 58 | 55 | 55 | 52 | 63 | 60 | 56 | 51 |
| Max. | 80 | 83 | 73 | 88 | 82 | 83 | 87 | 88 | 93 | 66 | 73 | 77 | 83 | 87 | 78 | 82 | 82 | 82 | 83 | 79 | 75 | 75 | 80 | 78 | 80 | 80 | 81 | 77 | 78 | 74 | 75 |
| August.....Min. | 50 | 57 | 52 | 54 | 57 | 54 | 48 | 51 | 55 | 56 | 54 | 50 | 52 | 62 | 45 | 46 | 54 | 59 | 64 | 60 | 70 | 57 | 62 | 62 | 52 | 48 | 47 | 39 | 46 | 43 | 49 |
| Max. | 78 | 79 | 78 | 71 | 73 | 76 | 79 | 81 | 82 | 76 | 80 | 78 | 83 | 76 | 77 | 67 | 80 | 84 | 84 | 89 | 82 | 88 | 85 | 72 | 77 | 78 | 70 | 72 | 68 | 68 | 78 |
| September..Min. | 49 | 46 | 56 | 34 | 54 | 38 | 42 | 54 | 47 | 40 | 35 | 41 | 54 | 58 | 63 | 60 | 62 | 41 | 45 | 48 | 49 | 41 | 40 | 52 | 53 | 41 | 35 | 56 | 42 | 45 | |
| Max. | 76 | 82 | 64 | 68 | 68 | 75 | 76 | 63 | 60 | 67 | 70 | 67 | 66 | 74 | 76 | 75 | 74 | 75 | 79 | 77 | 72 | 72 | 72 | 72 | 58 | 62 | 68 | 71 | 58 | 50 | |
| October.....Min. | 39 | 28 | 35 | 31 | 27 | 23 | 28 | 28 | 38 | 33 | 44 | 54 | 53 | 63 | 37 | 26 | 21 | 21 | 36 | 53 | 36 | 21 | 22 | 33 | 34 | 39 | 33 | 38 | 42 | 45 | 43 |
| Max. | 57 | 45 | 61 | 49 | 50 | 59 | 67 | 67 | 68 | 80 | 79 | 63 | 73 | 83 | 54 | 58 | 60 | 62 | 60 | 61 | 55 | 56 | 52 | 41 | 55 | 55 | 53 | 48 | 54 | 64 | 57 |
| November...Min. | 31 | 29 | 23 | 31 | 27 | 37 | 34 | 21 | 33 | 42 | 34 | 35 | 24 | 25 | 15 | 18 | 12 | 24 | 33 | 25 | 34 | 39 | 47 | 37 | 33 | 29 | 39 | 18 | 13 | 20 | |
| Max. | 55 | 53 | 52 | 58 | 69 | 67 | 61 | 64 | 58 | 53 | 60 | 37 | 42 | 45 | 33 | 34 | 46 | 55 | 59 | 60 | 67 | 72 | 63 | 63 | 59 | 45 | 48 | 50 | 35 | 41 | |
| December...Min. | 15 | 23 | 7 | 8 | 21 | 32 | 13 | 43 | 41 | 25 | 28 | 18 | 19 | 34 | 4 | —8 | 14 | 3 | 25 | 14 | 20 | —5 | —16 | —7 | 20 | 19 | 31 | 22 | 16 | 14 | 24 |
| Max. | 45 | 45 | 27 | 43 | 38 | 55 | 45 | 58 | 43 | 43 | 30 | 48 | 58 | 50 | 12 | 21 | 25 | 33 | 28 | 28 | 28 | 20 | 2 | 21 | 31 | 35 | 39 | 28 | 30 | 31 | 33 |

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# 1884.

| Days. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Months. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| January.....Min. | 21 | 24 | 17 | 4 | 2 | —7 | —7 | —11 | 40 | 21 | 25 | 9 | —2 | 36 | 6 | —2 | —2 | 19 | 9 | —8 | —12 | 14 | 24 | 10 | —2 | 4 | 1 | 7 | 20 | 19 | 29 |
| Max. | 31 | 36 | 31 | 15 | 15 | 8 | 7 | 15 | 60 | 30 | 39 | 21 | 22 | 40 | 18 | 14 | 25 | 42 | 20 | 21 | 17 | 28 | 38 | 40 | 20 | 18 | 20 | 15 | 26 | 34 | 48 |
| February....Min. | 31 | 7 | 17 | 19 | 18 | 27 | 34 | 19 | 20 | 26 | 21 | 24 | 28 | 35 | 20 | 4 | 23 | 35 | 29 | 34 | 12 | 19 | 32 | 5 | 7 | 21 | 27 | 26 | 4 | | |
| Max. | 31 | 25 | 31 | 21 | 32 | 41 | 45 | 21 | 34 | 40 | 31 | 38 | 34 | 56 | 30 | 36 | 41 | 45 | 43 | 45 | 38 | 38 | 36 | 22 | 27 | 31 | 48 | 32 | 18 | | |
| March..... Min. | 0 | —10 | —13 | 5 | —14 | 17 | 21 | 22 | 17 | 20 | 13 | 39 | 27 | 33 | 31 | 12 | 18 | 28 | 17 | 31 | 26 | 21 | 26 | 36 | 33 | 27 | 35 | 38 | 35 | 9 | 15 |
| Max. | 20 | 22 | 31 | 28 | 37 | 41 | 30 | 28 | 33 | 35 | 37 | 50 | 50 | 50 | 45 | 48 | 41 | 42 | 37 | 55 | 56 | 61 | 60 | 54 | 59 | 41 | 42 | 48 | 52 | 21 | 37 |
| April.....Min. | 25 | 26 | 29 | 35 | 35 | 29 | 33 | 36 | 34 | 35 | 34 | 32 | 26 | 35 | 32 | 41 | 44 | 43 | 41 | 43 | 45 | 28 | 31 | 33 | 44 | 46 | 39 | 33 | 38 | 39 | |
| Max. | 48 | 34 | 40 | 40 | 37 | 54 | 53 | 51 | 40 | 47 | 52 | 54 | 57 | 65 | 55 | 67 | 49 | 46 | 47 | 48 | 47 | 54 | 65 | 69 | 55 | 73 | 70 | 62 | 52 | 69 | |
| May..... Min. | 38 | 42 | 43 | 40 | 44 | 45 | 43 | 40 | 51 | 45 | 44 | 41 | 40 | 35 | 50 | 35 | 40 | 46 | 40 | 54 | 58 | 52 | 56 | 60 | 58 | 51 | 47 | 51 | 39 | 31 | 30 |
| Max. | 69 | 74 | 61 | 68 | 56 | 63 | 52 | 44 | 66 | 60 | 63 | 60 | 64 | 67 | 60 | 62 | 57 | 67 | 79 | 62 | 76 | 81 | 72 | 84 | 73 | 71 | 73 | 58 | 51 | 49 | 64 |
| June.....Min. | 40 | 39 | 47 | 56 | 56 | 62 | 60 | 58 | 65 | 59 | 56 | 52 | 52 | 46 | 38 | 48 | 58 | 56 | 62 | 62 | 63 | 62 | 50 | 61 | 69 | 56 | 47 | 50 | 54 | 57 | |
| Max. | 68 | 73 | 79 | 81 | 85 | 86 | 84 | 86 | 84 | 59 | 66 | 62 | 68 | 64 | 70 | 77 | 89 | 90 | 88 | 84 | 90 | 80 | 81 | 84 | 75 | 69 | 77 | 83 | 87 | 89 | |
| July.....Min. | 61 | 68 | 65 | 58 | 61 | 66 | 60 | 54 | 61 | 61 | 56 | 60 | 58 | 55 | 57 | 53 | 59 | 56 | 57 | 56 | 51 | 53 | 65 | 61 | 47 | 55 | 54 | 58 | 56 | 58 | 53 |
| Max. | 86 | 91 | 83 | 82 | 81 | 80 | 71 | 68 | 76 | 77 | 82 | 82 | 74 | 69 | 70 | 69 | 74 | 76 | 79 | 70 | 65 | 77 | 82 | 87 | 76 | 77 | 73 | 70 | 63 | 76 | 80 |
| August.....Min. | 62 | 52 | 53 | 61 | 70 | 68 | 58 | 61 | 57 | 52 | 56 | 52 | 58 | 59 | 54 | 59 | 64 | 64 | 65 | 66 | 68 | 72 | 63 | 58 | 44 | 52 | 55 | 46 | 57 | 64 | 64 |
| Max. | 76 | 79 | 84 | 80 | 78 | 80 | 75 | 79 | 72 | 71 | 70 | 72 | 64 | 75 | 87 | 83 | 88 | 91 | 88 | 88 | 91 | 88 | 78 | 69 | 68 | 68 | 72 | 76 | 77 | 80 | 76 |
| September...Min. | 54 | 46 | 54 | 61 | 66 | 56 | 63 | 62 | 62 | 64 | 64 | 59 | 42 | 35 | 37 | 45 | 58 | 48 | 39 | 52 | 46 | 36 | 50 | 47 | 58 | 44 | 41 | 60 | 65 | 51 | |
| Max. | 70 | 71 | 84 | 87 | 85 | 88 | 73 | 85 | 83 | 88 | 71 | 69 | 60 | 59 | 61 | 77 | 76 | 68 | 65 | 66 | 64 | 69 | 55 | 58 | 68 | 71 | 69 | 78 | 60 | 72 | |
| October.....Min. | 59 | 52 | 45 | 45 | 57 | 38 | 46 | 44 | 40 | 26 | 34 | 54 | 53 | 40 | 33 | 27 | 40 | 29 | 30 | 36 | 46 | 40 | 41 | 36 | 27 | 28 | 31 | 58 | 34 | 38 | 36 |
| Max. | 80 | 60 | 50 | 77 | 60 | 56 | 59 | 65 | 51 | 60 | 70 | 73 | 70 | 51 | 46 | 43 | 58 | 53 | 45 | 77 | 78 | 74 | 55 | 46 | 42 | 52 | 55 | 62 | 56 | 40 | 41 |
| November...Min. | 32 | 38 | 30 | 18 | 39 | 24 | 22 | 35 | 19 | 21 | 27 | 41 | 28 | 33 | 19 | 35 | 28 | 20 | 19 | 23 | 13 | 23 | 29 | 37 | 17 | 25 | 25 | 32 | 37 | 26 | |
| Max. | 47 | 52 | 54 | 46 | 49 | 36 | 44 | 38 | 49 | 62 | 60 | 55 | 53 | 47 | 63 | 58 | 59 | 38 | 27 | 38 | 46 | 48 | 58 | 42 | 34 | 42 | 38 | 40 | 41 | 41 | |
| December...Min. | 25 | 14 | 13 | 26 | 25 | 27 | 51 | 42 | 32 | 19 | 27 | 28 | 23 | 6 | 34 | 31 | 8 | —1 | —17 | —8 | 32 | 22 | 6 | 10 | 5 | —13 | 16 | 32 | 32 | 28 | 40 |
| Max. | 45 | 43 | 43 | 53 | 59 | 54 | 56 | 46 | 40 | 37 | 38 | 33 | 29 | 38 | 48 | 40 | 18 | 1 | 7 | 32 | 40 | 22 | 16 | 20 | 25 | 16 | 32 | 52 | 51 | 31 | 58 |

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SNOW.

| | 1856-7 | 1857-8 | 1858-9 | 1859-60 | 1860-1 | 1861-2 | 1862-3 | 1863-4 | 1864-5 | 1865-6 | 1866-7 | 1867-8 | 1868-9 | 1869-70 | 1870-1 | 1871-2 | 1872-3 | 1873-4 | 1874-5 | 1875-6 | 1876-7 | 1877-8 | 1878-9 | 1879-80 | 1880-1 | 1881-2 | 1882-3 | 1883-4 | 1884-5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| October.....Inches | | | | | | | | | | 8 | | | 3 | | 1 | | | | | | | | | | | | | | |
| November..... " | 7 | 1 | 6 | | | 7 | 4 | | 7 | 1 | 4 | 4 | 4 | 1 | | 11 | 18 | 25 | 7 | 13 | | 3 | | 23 | | 5 | 10 | 3 | |
| December..... " | 11 | 12 | 13 | 32 | 82 | 18 | 11 | 16 | 26 | 14 | 14 | 11 | 12 | 17 | 8 | 16 | 33 | 26 | 7 | 8 | 43 | 2 | 14 | 20 | 18 | 5 | 13 | 18 | 7 |
| January..... " | 33 | 8 | 36 | 35 | 85 | 33 | 14 | 6 | 25 | 14 | 22 | 26 | 21 | 17 | 9 | 8 | 19 | 14 | 34 | 8 | 22 | 19 | 27 | 12 | 29 | 32 | 15 | 14 | 18 |
| February..... " | 6 | 16 | 18 | 16 | 9 | 23 | 14 | 9 | 18 | 5 | 10 | 11 | 26 | 30 | 16 | 17 | 22 | 18 | 15 | 32 | | 24 | 16 | 12 | 13 | 38 | 23 | 28 | |
| March..... " | 7 | 10 | 10 | 6 | 24 | 10 | 43 | 7 | | 8 | 21 | 17 | 19 | 20 | 5 | 16 | 21 | 4 | 34 | 27 | 7 | 2 | 28 | 12 | 19 | 6 | 11 | 20 | |
| April..... " | 4 | 4 | 5 | | 10 | 6 | 3 | 16 | | 1 | 1 | 16 | | 1 | | | 2 | 35 | 6 | 12 | | | 12 | | 4 | 4 | 6 | 8 | |
| Total Inches | 68 | 51 | 83 | 89 | 110 | 97 | 89 | 54 | 76 | 46 | 72 | 85 | 85 | 86 | 39 | 68 | 115 | 122 | 103 | 100 | 72 | 50 | 97 | 79 | 83 | 90 | 78 | 88 | |

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## RAIN-FALL.

| | 1856 | 1857 | 1858 | 1859 | 1860 | 1861 | 1862 | 1863 | 1864 | 1865 | 1866 | 1867 | 1868 | 1869 | 1870 | 1871 | 1872 | 1873 | 1874 | 1875 | 1876 | 1877 | 1878 | 1879 | 1880 | 1881 | 1882 | 1883 | 1884 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Inches January .. | .00 | .00 | 3.21 | .00 | .00 | .15 | .00 | 2.50 | .60 | 1.71 | .00 | .00 | .22 | .74 | 4.30 | .00 | .60 | 2.70 | 1.82 | .00 | 1.47 | .00 | 2.40 | .00 | 3.15 | .61 | .67 | .40 | 2.82 |
| February.. | .00 | .00 | .00 | .00 | .53 | .00 | .00 | 2.21 | .14 | .53 | 2.84 | 1.05 | .05 | .37 | 1.50 | .93 | .00 | .00 | 1.55 | 1.03 | 2.67 | .40 | 2.02 | 1.45 | 1.38 | 2.35 | .48 | .18 | 2.98 |
| March .... | .00 | .87 | 46 | .00 | .46 | 1.79 | 1.79 | 1.75 | 4.26 | 4.02 | 1.67 | 1 20 | .65 | 2 79 | 1.13 | 3.18 | .80 | .72 | .33 | 1.15 | 5.48 | 4.58 | 2 10 | .25 | .20 | 1.93 | 2.13 | .40 | 2.51 |
| April ..... | 2.00 | 5.32 | 1.02 | .68 | 1.50 | 4.40 | 2.39 | 3.22 | 2.39 | 2.61 | 1.35 | 3.43 | 1.10 | 1.45 | 6.15 | 4.70 | 1.45 | 1.77 | 1.30 | 2.63 | 1.20 | 3.26 | 6.70 | 1.90 | 2.62 | .55 | .69 | 1.82 | 2.73 |
| May ..... | 5.14 | 5.97 | 3.32 | .00 | 2.20 | 3.83 | 2 72 | 2.52 | 2.37 | 5.41 | 3 55 | 3.85 | 6.81 | 3.18 | 1.74 | 3.04 | 2.49 | 2.15 | 4.19 | 2.77 | 3.22 | 2.96 | 1.86 | 4.51 | 1.63 | 3.23 | 4.07 | 3.04 | 3.07 |
| June..... | 2.59 | 3.20 | 3.96 | 6.74 | 3.23 | 1.66 | 7.95 | 4.12 | .72 | 2.55 | 3 14 | 2 05 | 2.52 | 1.54 | 2.20 | 2.47 | 4.61 | .89 | 4.74 | 3.97 | 4.89 | 2.63 | 5.10 | 4.76 | 1 33 | 3.34 | 3 98 | 2.04 | .93 |
| July ..... | 2.35 | 4.81 | 4.57 | 3.36 | 3.10 | 5.61 | 4.74 | 6.82 | 1.31 | 3 76 | 3.66 | 4 59 | 3.05 | 1.14 | 1.40 | 4.20 | 7.72 | 4.08 | 6.54 | 2.43 | 4 73 | 4.77 | 1.84 | 4.29 | 3.55 | 4 38 | 1.73 | 5.80 | 2.14 |
| August.... | 13.32 | 3.00 | 4.22 | 4.39 | 4 71 | 3 52 | 3.57 | 6.35 | 5.71 | 3.30 | 3.89 | 9.90 | 2.89 | 2 01 | 1.23 | 5.02 | 7.00 | 1.85 | 1 95 | 5.31 | .42 | 4.37 | 4.06 | 4.39 | 1.47 | 1 25 | .35 | 1.37 | 3.62 |
| September | 3.60 | 2.40 | 5.97 | 5 56 | 3.78 | 3.05 | 3.12 | 2.69 | 3.33 | 2.00 | 5 03 | 1.54 | 9.92 | 3.46 | 1.94 | 1.30 | 4.32 | 4.06 | 2 40 | 2.92 | 3.82 | .85 | .71 | 3.28 | 3.12 | 3.52 | 7.22 | 1.96 | .76 |
| October... | 2.05 | 5.12 | 3.79 | 2.78 | 3.13 | 6 86 | 5.40 | 5.15 | 4.30 | 4.76 | 2.59 | 3.42 | .36 | 11 65 | 2 17 | 4.73 | 4.63 | 6.05 | 1.37 | 6.17 | .95 | 7.62 | 4.09 | .79 | 3.98 | 2.96 | 1.41 | 3.67 | 1.79 |
| November | .44 | 2.20 | 1.19 | 2.90 | 5.05 | 2.50 | 7.24 | 6.73 | 5.17 | 1 55 | 3.70 | 2.05 | 5 14 | 2.10 | 2.39 | 2 75 | 3 30 | .65 | 1.70 | 1.95 | 2.56 | 5 93 | 5.76 | 1.95 | 2.01 | 2.74 | .19 | 1.87 | 2.18 |
| December | .00 | 1.17 | .14 | .10 | .30 | .11 | .86 | 2.15 | 2.03 | 1.45 | 1.86 | .82 | .55 | 2.60 | 1.37 | 1.90 | .25 | .78 | .20 | .28 | .00 | .64 | 5.15 | 1.97 | .64 | 5 39 | .53 | .75 | 2.51 |
| Total.... | 31.49 | 34.06 | 32.45 | 26.51 | 27.99 | 38.45 | 39.78 | 46.21 | 32.33 | 33 65 | 33.71 | 33.90 | 33.26 | 33.08 | 27.52 | 34.22 | 37.17 | 25.70 | 28.09 | 30.61 | 31.36 | 38.03 | 41.79 | 29.54 | 25 08 | 32.30 | 23.45 | 23.30 | 28.04 |

## RAIN AND MELTED SNOW.

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total ... | ..... | 39.34 | 36.98 | 34.65 | 36.84 | 42.53 | 47.00 | 34.09 | 41.91 | 38.89 | 36.50 | 40.23 | 40.80 | 40.03 | 33.84 | 38.82 | 45.03 | 35.27 | 35.23 | 39.81 | 43.55 | 40.69 | 27.68 | 35.90 | 29.66 | 39.87 | 32.04 | 29.47 | 35.51 |

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## AVERAGE MINIMUM TEMPERATURE.

| | 1857 | 1858 | 1859 | 1860 | 1861 | 1862 | 1863 | 1864 | 1865 | 1866 | 1867 | 1868 | 1869 | 1870 | 1871 | 1872 | 1873 | 1874 | 1875 | 1876 | 1877 | 1878 | 1879 | 1880 | 1881 | 1882 | 1883 | 1884 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| January | 3 | 19 | 15 | 18 | 11 | 12 | 19 | 16 | 6 | 10 | 4 | 8 | 15 | 18 | 8 | 14 | 5 | 13 | —1 | 18 | —5 | 12 | 9 | 20 | 4 | 10 | 8 | 9 |
| February | 22 | 9 | 18 | 15 | 22 | 8 | 15 | 19 | 16 | 17 | 19 | 1 | 17 | 13 | 11 | 6 | 5 | 11 | 1 | 12 | 17 | 14 | 11 | 17 | 12 | 14 | 10 | 21 |
| March | 24 | 22 | 32 | 29 | 23 | 23 | 13 | 25 | 28 | 26 | 19 | 19 | 11 | 17 | 29 | 11 | 16 | 21 | 14 | 21 | 22 | 27 | 22 | 22 | 29 | 24 | 12 | 19 |
| April | 33 | 35 | 38 | 35 | 35 | 31 | 31 | 33 | 38 | 40 | 32 | 29 | 32 | 30 | 32 | 32 | 28 | 29 | 29 | 32 | 35 | 41 | 29 | 35 | 31 | 29 | 31 | 35 |
| May | 47 | 47 | 49 | 48 | 43 | 43 | 45 | 48 | 46 | 45 | 42 | 42 | 42 | 40 | 43 | 47 | 43 | 43 | 45 | 44 | 45 | 45 | 49 | 52 | 48 | 38 | 44 | 45 |
| June | 56 | 61 | 57 | 59 | 53 | 49 | 49 | 52 | 58 | 51 | 55 | 54 | 53 | 57 | 51 | 59 | 54 | 58 | 54 | 60 | 58 | 52 | 55 | 54 | 51 | 54 | 58 | 55 |
| July | 64 | 61 | 61 | 58 | 62 | 55 | 60 | 58 | 56 | 58 | 58 | 64 | 59 | 60 | 56 | 65 | 62 | 61 | 59 | 65 | 63 | 62 | 60 | 60 | 60 | 60 | 59 | 58 |
| August | 58 | 59 | 51 | 61 | 58 | 54 | 58 | 59 | 53 | 50 | 60 | 60 | 56 | 50 | 56 | 64 | 54 | 59 | 61 | 60 | 58 | 58 | 57 | 56 | 61 | 58 | 53 | 60 |
| September | 51 | 52 | 48 | 49 | 48 | 49 | 48 | 47 | 51 | 47 | 47 | 54 | 46 | 56 | 42 | 50 | 52 | 47 | 47 | 50 | 12 | 52 | 49 | 53 | 59 | 54 | 47 | 52 |
| October | 41 | 42 | 33 | 40 | 44 | 41 | 39 | 34 | 33 | 34 | 33 | 32 | 37 | 38 | 37 | 40 | 39 | 39 | 39 | 35 | 41 | 44 | 44 | 36 | 41 | 42 | 35 | 40 |
| November | 32 | 32 | 30 | 34 | 30 | 32 | 33 | 30 | 33 | 28 | 26 | 24 | 25 | 29 | 21 | 28 | 18 | 25 | 21 | 32 | 31 | 30 | 29 | 25 | 31 | 28 | 29 | 30 |
| December | 27 | 17 | 14 | 18 | 21 | 19 | 16 | 21 | 22 | 14 | 8 | 12 | 18 | 19 | 10 | 8 | 15 | 14 | 19 | 6 | 21 | 21 | 20 | 34 | 26 | 15 | 16 | 11 |
| Total average | 38 | 37 | 36 | 35 | 37 | 32 | 35 | 37 | 37 | 35 | 34 | 32 | 35 | 35 | 33 | 36 | 35 | 35 | 32 | 36 | 37 | 38 | 36 | 37 | 38 | 35 | 33 | 37 |

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## AVERAGE MAXIMUM TEMPERATURE.

| | 1869 | 1870 | 1871 | 1872 | 1873 | 1874 | 1875 | 1876 | 1877 | 1878 | 1879 | 1880 | 1881 | 1882 | 1883 | 1884 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| January | 35 | 40 | 30 | 34 | 38 | 35 | 37 | 36 | 31 | 38 | 29 | 42 | 30 | 29 | 24 | 28 |
| February | 43 | 32 | 37 | 42 | 36 | 35 | 34 | 35 | 47 | 41 | 31 | 40 | 36 | 33 | 34 | 34 |
| March | 40 | 41 | 49 | 35 | 41 | 45 | 30 | 43 | 44 | 49 | 40 | 42 | 45 | 44 | 35 | 41 |
| April | 59 | 63 | 59 | 59 | 52 | 48 | 51 | 55 | 60 | 60 | 52 | 60 | 56 | 53 | 56 | 53 |
| May | 69 | 71 | 69 | 70 | 77 | 77 | 79 | 79 | 66 | 68 | 73 | 77 | 73 | 63 | 69 | 64 |
| June | 73 | 83 | 75 | 74 | 75 | 74 | 76 | 80 | 83 | 75 | 70 | 79 | 71 | 76 | 79 | 78 |
| July | 80 | 84 | 93 | 86 | 80 | 79 | 79 | 85 | 79 | 84 | 81 | 84 | 80 | 83 | 80 | 76 |
| August | 77 | 85 | 79 | 82 | 76 | 77 | 81 | 82 | 80 | 78 | 77 | 79 | 77 | 84 | 77 | 77 |
| September | 73 | 77 | 69 | 72 | 69 | 73 | 70 | 68 | 75 | 73 | 70 | 77 | 74 | 73 | 69 | 72 |
| October | 59 | 65 | 62 | 60 | 65 | 64 | 60 | 57 | 60 | 64 | 70 | 62 | 61 | 65 | 59 | 68 |
| November | 49 | 53 | 44 | 47 | 39 | 49 | 42 | 51 | 53 | 46 | 47 | 46 | 49 | 49 | 53 | 46 |
| December | 38 | 37 | 33 | 27 | 36 | 35 | 37 | 30 | 44 | 36 | 37 | 33 | 43 | 37 | 34 | 36 |
| Total Average | 58 | 61 | 54 | 53 | 58 | 54 | 55 | 58 | 60 | 60 | 57 | 60 | 58 | 58 | 54 | 53 |

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# EXPERIMENTAL WORK.

We give a few reports of experiments performed at home and abroad, and with them the tested formulas of some of our most successful men.

## ON THE SECRETARY'S FARM, BOSCAWEN.

BY W. O. SMITH.

On corn, light, sandy loam, with clay sub-soil, formerly a pasture, grown up to pines and birches, and cut off, plowed the year before, and planted with potatoes, no manure either year. Comparison made with six brands of special fertilizers, on grain and stalk, 250 hills each, with results as follows:

RESULT IN GRAIN.

| | |
|---|---|
| Cotton-seed meal taken at | 100 |
| Buffalo for potatoes | 79⅞ |
| Clark's Cove phosphate | 71½ |
| Pacific guano | 58⅝ |
| Buffalo phosphate for corn | 53⅜ |
| Bradley's XL | 43⅜ |
| Nothing | 42½ |

It will be seen that cotton-seed meal gave the most corn. Equal values were applied; at first the cotton seed had no marked effect, but at length responded generously. The "Buffalo" made for potatoes had better effect on corn than that made for corn. It contains more potash, and on this kind of soil potash is needed. It is worthy of notice that this brand

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was second in grain product and third in stalk. Clark's Cove, a new article made in New Bedford, proved to be third in grain but second in stalk.

RESULT IN STALK.

| | |
|---|---|
| Pacific guano | 100 |
| Clark's Cove | 99⅓ |
| Buffalo for potatoes | 91⅓ |
| Bradley's XL | 89⅐ |
| Buffalo for corn | 86⅐ |
| Cotton-seed meal | 78⅜ |
| Nothing | 40⅖ |

This gives confidence in cotton-seed meal for this land. A combination of cotton seed and Pacific guano would evidently be a judicious application. Some quick acting phosphate like Bradley's would be a good complement to cotton seed.

Now let it be understood that this result is on a specific soil. Nothing is determined for other soils. Each experimenter must do this for himself.

ANOTHER EXPERIMENT.

Stockbridge compared with stable manure.

| | Stockbridge. | Green manure. | Old manure. |
|---|---|---|---|
| Potatoes, | 63½ lbs. | 58½ lbs. | 33 lbs. |
| Corn | 47 | 41½ | 21 |
| Stover | 117 | 94½ | 54 |

The same value being used.

## CORN EXPERIMENTS, 1883.

BY C. HERBERT HAZEN, HARTFORD, VT., A GRADUATE OF THE N. H. COLLEGE OF AGRICULTURE, 1881.

These experiments were made on plots 4 rods long by 2 rods wide, and on unmanured land. The land was somewhat sloping. The plots were arranged as follows:

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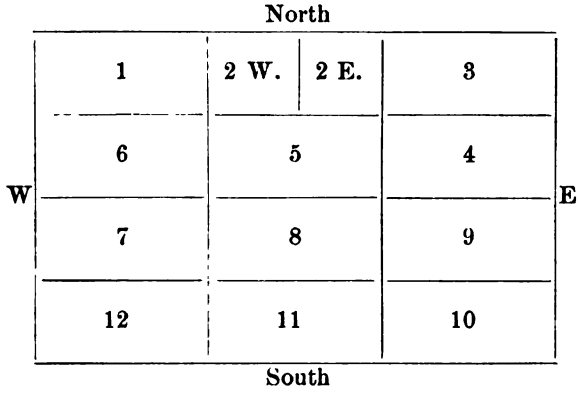


It will be seen from the account of the plots that the yield is the best at the north-east corner. I account for this in part from the fact that the land is the most fertile there, and I think decreases in fertility toward the south-west. The difference certainly could not have been so great as it appears: so we must consider that the fertilizers caused the difference in the yield, to a great extent at least, though not wholly. I think the Nothing plots were better than the average of the piece, which accounts for their yield being better than some of the fertilized plots. In plot 3 (which gives the largest yield) the fertilizers were mixed well, and dropped in the hill and covered before the corn was dropped. I expected plot 4 (same as plot 3 except that the fertilizer was sowed) would give me a better yield than plot 3, but it never quite caught up with it, though I think it gained on it the last of the season. It is my opinion that a small part of the fertilizer should be put in the hill, and the rest sowed broadcast. The ingredients of plot 11 were mixed together and moistened, and left two weeks to decompose before using. The Nova Scotia plaster used in plots 3, 4, and 11, was used to hold the ammonia. I consider it of no value of itself except to fix the volatile compounds of nitrogen or ammonia. Plot 8 shows no benefit from its use.

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| Nos. | | Amount of fertilizer per acre in lbs. | Cost per acre. | Bushels of shelled corn per acre. |
|---|---|---|---|---|
| 1 | Nothing | | | 36.5 |
| 2 E. | Muriate of potash | 160 | $3.20 | 43.7 |
| 2W½ | Blue plaster | 400 | 2.00 | 37.3 |
| 3 In hills | Dissolved bone black, hen manure, and plaster | 200<br>500 | 6.50 | 57 |
| 4 | Same as No. 3, but sowed | | 6.50 | 50 |
| 5 | Dis. bone black | 200 | 3.30 | 34.9 |
| 6 | Bradley's phosphate | 400 | 9.00 | 35.9 |
| 7 | Quinnipiac phosphate | 400 | 9.00 | 28.4 |
| 8 | Sulphate of lime (plaster) | 400 | 1.60 | 26 |
| 9 | Dis. bone meal | 300 | 6.75 | 41.3 |
| 10 | Nothing | | | 35.7 |
| 11 | Ashes<br>Bone meal (fine ground)<br>Plaster | 600<br>300<br>100 | 8.90 | 32.5 |
| 12 | Dis. bone meal<br>Potash | 100<br>160 | 4.85 | 25 |
| 13 | Manured and same fertilizer as rest of piece | | | 50.4 |

These experiments were made with the view of ascertaining the elements of plant-food required by the soil here. They seem to show that the soil is deficient in phosphoric acid and nitrogen, and possibly potash, but that is not certain. That the soil lacks nitrogen is certain from the plots 3 and 4, and from another plot, not in the table, on which was applied a fair coat of stable manure and dissolved bone-black and hen manure sowed. The yield was not equal to either plots 3 or 4. They also show that we can supply the elements needed in much cheaper forms than by buying the commercial fertilizers or phosphates. The land, in this part of Hartford at least, I think is deficient in phosphoric acid. Some of the cheapest forms in which it can be obtained are in the forms of dissolved bone-black, ground bone meal (fine ground), South Carolina rock (ground and dissolved), and acid phosphate. Any one of these,

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used judiciously with stable manure or some other form of nitrogen, will pay the farmer its cost and generally much more. Ground bone-meal would be the best to use alone. If quick returns are desired, it would be better to dissolve it in sulphuric acid.

## MR. BELL'S SEEDING TRIAL.

Planted eight rows of Late Rose potatoes with the following seed, as an experiment, not expecting to settle the question of quantity or character of seed for the best results, yet thought it not impossible that the product would afford some interest to the practical farmer. I put in the hills one large spoonful of Bradley's phosphate, but nothing else in the way of fertilizer either in the hill or broadcast. The rows were of five hills each, as follows:

First row, one eye in each hill.
Second row, two eyes in each hill.
Third row, three eyes in each hill.
Fourth row, seed end of a medium potato in each hill.
Fifth row, butt end of a medium potato in each hill.
Sixth row, one very small potato in each hill.
Seventh row, one medium sized potato in each hill.
Eighth row, one large potato in each hill.

They were hoed the first time on the tenth of June, and twice thereafter, and dug on August 29, with the following result, viz.,—

Product of first row, 15½ lbs., there being 30 large and 5 small potatoes.

Product of second row, 15½ lbs., with 40 large and 5 small potatoes.

Product of third row, 13½ lbs., with 45 marketable potatoes and 5 small ones.

Product of fourth row, 13 lbs., with 50 average medium size and 28 very small.

Product of fifth row, 15½ lbs., with 47 medium and 15 small.

Product of sixth row, 11¾ lbs., with 45 fair to medium and 8 small.



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Product of seventh row, 12¾ lbs., with 48 medium and 16 small.

Product of eighth row, 22¾ lbs., with 80 fair to medium and 47 little ones.

The total product is not at all remarkable, and for the reason that the ground had no manure except as named; but that did not form any part of the experiment, viz., to obtain a large crop and gain space of ground, but only to see what a given amount of seed would do under a uniform condition of treatment.

## MR. GREGORY'S FORMULAS.

Mr. J. J. H. Gregory, the veteran seedsman of Massachusetts, recently gave the following formulas for fertilizing given crops:

For corn, 600 lbs. bone phosphate, $9.30; 200 lbs. cotton-seed meal, $1.80; 160 lbs. sulphate of ammonia, $5.80; 180 lbs. muriate of potash, $2.22;—total cost, $19.12 per acre. These materials were thoroughly mixed together. Half the quantity was applied broadcast and harrowed in; the rest was sowed in the drill, and covered lightly before the seed was dropped.

For grass, 400 lbs. bone phosphate, $6.20; 100 lbs. dried blood, $2.08; 100 lbs. sulphate of ammonia, $3.63; 150 lbs. muriate of potash, $1.97;—total cost per acre, $13.88. This was applied as a top-dressing, and gave excellent results. The ammonia in the form of sulphate started the grass, and that in the form of blood backed up the crop.

For onions, 700 lbs. bone, $10.85; 100 lbs. dried blood, $2.08; 400 lbs. cotton-seed meal, $3.60; 200 lbs. muriate of potash, $2.47;—total cost, $19. This dressing was used where no other manure had been applied. As the onions began to bottom, 300 lbs. of pure guano, or 250 lbs. sulphate of ammonia, were strewn between the rows and cultivated in, at a further cost of $9, making the whole cost for manure, $28.

For oats, 300 lbs. plain bone phosphate, $4.65; 150 lbs. dried blood, $3.12; 25 lbs. sulphate of ammonia, 91 cents; 35 bushels unleached wood ashes, $11.20;—total cost, $19.88 per acre.

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For vines, such as watermelon, squash, cucumber, and pumpkin, 600 lbs. plain bone phosphate, $9.30; 100 lbs. sulphate of ammonia, $3.63; 100 lbs. dried blood, $2.08; 200 lbs. cotton-seed meal, $1.80; 200 lbs. muriate of potash, $2.47;—total cost, $19.28 per acre.

For tomatoes, 1,000 lbs. coarse cotton-seed meal, $9; 400 lbs. dissolved rock phosphate, $4; 20 bushels unleached wood ashes, $6.40;—total cost, $19.40 per acre.

For carrots or beets, 400 lbs. phosphate, $6.20; 100 lbs. sulphate ammonia, $3.63; 100 lbs. dried blood, $2.08; 200 lbs. cotton-seed, $1.80; 160 lbs. muriate of potash, $2.16;—total cost, $15.87.

Beans, 550 lbs. phosphate, $9; 33 lbs. sulphate ammonia, $1.15; 110 lbs. muriate of potash, $1.45;—total cost, $11.60 per acre.

Hungarian grass or millet, 400 lbs. bone phosphate, $6.20; 150 lbs. muriate of potash, $1.97; 50 lbs. sulphate of ammonia, $1.82;—total cost, $9.99 per acre. This gave good results for two years.

For pease, 600 lbs. phosphate, $9.30; 250 lbs. muriate of potash, $3.05; 40 lbs. dried blood, 83 cents;—total cost, $13.18.

For potatoes, 500 lbs. phosphate, $7.75; 50 lbs. sulphate of ammonia, $1.82; 75 lbs. cotton-seed or 50 lbs. guano, 75 cents; 200 lbs. muriate of potash, $2.47;—total cost, $12.77 per acre. This was applied in the drill.

For seed cabbage, 4 cords stable manure ploughed in, 4 cords fine manure in the drill, and 400 lbs. bone and 100 lbs. muriate of potash, both in the drill.

For seed onions, 5 cords of manure ploughed in, 600 lbs. bone in the drill, 100 lbs. muriate of potash stirred in by the cultivator and hoe.

## THE BEST RASPBERRIES.

Now that it has become very common for farmers, as well as amateurs, to grow small fruit, it is well to know the result of experiments which Dr. Sturtevant and Prof. Goff, of the New York station, have given in regard to raspberries:

In the year 1882, two plants each of twelve varieties of the raspberry were planted in the station garden. The plants were

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set out in rows six feet apart, and three feet apart in the row. No winter protection has been given. The soil has been cultivated sufficiently to keep down weeds, and the canes were tied to stakes, as they became sufficiently tall to require support.

All of these plans have survived thus far, except five—two Princkles Orange, which were winter-killed the first winter after setting, two American Blackcap, and one Prosser. The remainder of the plants have borne their first full crop the present season. I have kept a careful record of the date at which each variety commenced to ripen its fruit (column below marked No. 1), the number of days that each continued in bearing (3), and the total yield of each in ounces and decimals of an ounce (2), taking notes also as to the comparative size and quality of the fruit in the different varieties, which is shown by the weight of 25 samples, given in grains (4) :

| | 1 July | 2 | 3 | 4 |
|---|---|---|---|---|
| 1. Brandywine | 5 | 7.295 | 33 | 478 |
| 2. Caroline | 8 | 44.374 | 30 | 524 |
| 3. Clarke | 5 | 65.386 | 30 | 665 |
| 4. Cuthbert | 8 | 22.868 | 30 | 601 |
| 5. Davison's Thornless | 1 | 14.233 | 22 | 300 |
| 6. Delaware | 5 | 44.529 | 33 | 447 |
| 7. Early Prolific | 3 | 80.326 | 35 | 655 |
| 8. Fastolff | 5 | 19.843 | 26 | 540 |
| 9. Fontenay | 5 | 31.527 | 33 | 833 |
| 10. Franconia | 12 | 15.185 | 26 | 640 |
| 11. Gregg | 14 | 17.009 | 21 | 439 |
| 12. Herstein | 5 | 17.236 | 26 | 620 |
| 13. Henrietta | 5 | 19.654 | 26 | 617 |
| 14. Highland Hardy | 2 | 12.427 | 28 | 408 |
| 15. Knevett | 5 | 19.820 | 33 | 798 |
| 16. Mammoth Cluster | 10 | 26.392 | 25 | 331 |
| 17. Mrs. Wood | 3 | 36.035 | 35 | 733 |
| 18. Naomi | 3 | 1.323 | 28 | 234 |
| 19. Parnell | 5 | 26.667 | 30 | 540 |
| 20. Philadelphia | 8 | 6.420 | 23 | 127 |
| 21. * Prosser | 5 | 15.083 | 26 | 308 |
| 22. Palluau | 5 | 6.952 | 26 | 308 |
| 23. Red Antwerp | 3 | 18,556 | 35 | 555 |
| 24. Reliance | 5 | 17.242 | 26 | 432 |

* The yield from this variety is calculated from one plant.

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| | | | | |
|---|---|---|---|---|
| 25. Seneca | 10 | 29.030 | 25 | 347 |
| 26. Thwack | 3 | 29.085 | 35 | 710 |
| 27. Turner | 3 | 19.171 | 28 | 432 |
| 28. Vice-Pres. French | 5 | 38.865 | 30 | 586 |
| 29. Victoria | 5 | 37.090 | 33 | 563 |
| 30. Yellow Antwerp | 10 | 20.529 | 28 | 470 |

The following notes were made as to quality:

2. Delicate and pleasant, but not rich; moderately firm.
3. Rather sweet and delicate, but not rich; moderately firm.
4. Very sweet and rich; firm.
5. Sweet and rich; rather firm.
6. Rather soft; very sweet and delicate, resembling that of the wild red raspberry.
7. Flavor a well-marked, rather harsh acid; moderately firm.
8. Moderately rich, sweet; not very firm.
9. Extremely rich and sweet; moderately firm.
10. Rich and sprightly; moderately firm.
11. Flavor rather inferior; firm.
12. Sweet and delicate; moderately firm.
13. Insipid, with little raspberry flavor; moderately firm.
15. Very sweet and delicate; rather soft.
16. Insipid; firm.
17. Very rich, sweet and delicate; rather soft.
18. Very sweet, but lacking raspberry flavor; rather soft.
19. Lacks sweetness, richness, and raspberry flavor; moderately firm.
20. Rather insipid; moderately firm.
21. Very sweet and delicate; moderately firm.
22. Sweet, but leaves an acid taste in the mouth; moderately firm.
23. Moderately rich and sweet; rather soft.
24. Flavor insipid; moderately firm.
25. Rather insipid; firm.
26. Sweet and rich; quite firm.
27. Very sweet and delicate; moderately firm.
28. Extremely rich and sweet; moderately firm.
29. Extremely rich and sweet; moderately firm.
30. Delicate, but not high-flavored; very soft.

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It will be observed that our list is not confined to the newer varieties, but includes many of the older sorts as well.

The old Early Prolific proved by far the most productive. This variety, now little grown, possesses the valuable qualities of great prolificacy and hardness, with entire freedom from thorns; and though the harsh, acid flavor of its fruit makes the latter undesirable, it would seem that its good qualities might render it valuable as a parent for new varieties.

The Clarke proved second in productiveness, the Delaware third, and the Caroline fourth; the Philadelphia, Brandywine, and Naomi were least productive. Davison's Thornless was earliest to ripen, while Gregg was latest. Early Prolific, Mrs. Wood, and Red Antwerp continued longest in bearing, while Gregg yielded its crop in the shortest time.

It appears that the berries of Knevett (Knevett's Giant) were the largest, those of Mrs. Wood were second in size, while those of Naomi and Davison's Thornless were smallest. In flavor the Delaware seemed to surpass all others in the characteristic aroma of the wild raspberry and Fontenay. Vice-President French and Victoria were superior in richness and sweetness.

## ROTHAMSTED EXPERIMENTS.

The result of forty years' experimental work, by Gilbert & Laws, of Rothamstead, Eng., is here given in a condensed form.

### THE SOIL.

1. A soil, which in the ordinary course of agriculture would have received an application of manure before another crop was sown, has produced forty crops of wheat in succession, averaging 14 bushels per acre, solely by means of its existing fertility.

2. At the commencement of the experiment the soil contained a large amount of organic nitrogen derived from the débris of preëxisting vegetation. It also contained a large amount of the mineral food of plants.

3. Every year a certain proportion of the organic nitrogen has been nitrified by organisms existing in the soil.

4. Part of the nitrates formed has been employed in the growth of the wheat crop; part has washed out of the soil or otherwise lost.

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5. The loss of nitric acid is greater in wet seasons, and the amount taken up by the wheat crop is in consequence smaller. Dry seasons should therefore be favorable for the production of large crops of wheat.

6. The stock of soil fertility in the form of organic nitrogen has been considerably reduced during the forty years that the experiments have been carried on, and the amount of such reduction has been ascertained by analyses of the soil made at different periods. The stock of both potash and phosphoric acid has also been largely reduced.

7. Although so much soil fertility has been removed, the stock that remains would appear to be sufficient to grow crops of wheat for a very long period; the produce, however, must in process of time necessarily be lower than it has hitherto been.

MANURES.

8. Mineral manures alone have added very slightly to the produce grown upon the unmanured land.

9. Manures containing nitric acid alone, or some compound of nitrogen which is easily nitrified, have considerably increased the crop.

10. The soil, therefore, contained a stock of minerals which the wheat crop was unable to make use of, owing to the insufficient supply of nitrogen in some available form.

11. Manures consisting of potash, phosphoric acid, and ammonia, or nitrates, appear competent to grow large crops of wheat continuously.

12. A given weight of nitrogen as nitric acid has produced more growth in the wheat crop than the same weight of nitrogen in salts of ammonia.

13. The amount of nitrogen supplied in manures is very much in excess of the amount recovered in the increase of the crop.

14. After a certain amount of growth has been reached, each increase of crop requires a proportionately larger application of manure. When the price of grain is high, larger crops can be grown more profitably than when the price is low.

15. When farmyard dung is employed to grow wheat, a considerable larger amount of nitrogen must be applied to produce

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a given increase in the crop, as much of the nitrogen contained in the dung is not in an active form.

16. A given weight of nitrogen, in the form of nitric acid, will produce more growth in the crop to which it is applied than the same weight of nitrogen in dung; but the influence of the nitrate upon succeeding crops will be very much less.

17. There is no evidence to show whether the whole available effect of the nitrogen in one manure is greater than it is in the other.

### UNEXHAUSTED MANURES.

18. In the absence of vegetation, or when applied to crops in excess of their requirement, both potash and phosphoric acid form insoluble compounds with the soil, and become available for future crops.

19. In the absence of vegetation, or when the amount supplied is in excess of the requirements of the crop, nitrates and salts of ammonia do not appear to form permanent compounds with the soil, but, on the contrary are liable to be washed out by rain, or to be otherwise lost.

20. The application of a larger amount of nitrogen, as nitrates or salts of ammonia, than the crop could utilize, owing to a want of minerals, does not appear to prevent the nitrification of the organic nitrogen of the soil.

21. The stock of nitrogen of the soil itself, therefore, may be reduced, although the annual application of nitrogen may be much in excess of the amount of that substance removed in the crop.

22. When large crops of wheat have been grown by the application of nitrates or salts of ammonia with mineral manures, the soil does not appear to have gained or lost fertility. Nitrification of the organic matter in the soil may have gone on as usual, but the loss has been made good by the amount of nitrogen stored up in the stubble and underground roots of the large crops previously grown.

23. When dung is applied continuously to land, the accumulation of unexhausted fertility becomes very large, and the removal by crops of the substance accumulated would extend over a long series of years.

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24. Dung applied to land in the ordinary processes of agriculture will not be entirely exhausted until a considerable number of years have elapsed from the time of its first application.

## CHEMICALS TESTED.

### MURIATE OF POTASH.

| | |
|---|---|
| Potash, | 50.25 per cent. |
| Soda, | 11.25 " |

Traces of magnesia, sulphuric acid.

### SULPHATE OF AMMONIA.

| | |
|---|---|
| Ammonia, | 24.75 per cent. |

## FERTILIZERS TESTED.

### COMMON-SENSE FERTILIZER.

| | |
|---|---|
| Nitrogen, | 3.87 per cent. |
| Potash, | 3.37 " |
| Phosphoric acid, | 5.30 " |
| Sale price, | $38.00 |
| Real value, | 30.68 |

Not now licensed.

### BRADLEY'S XL.

| | |
|---|---|
| Nitrogen, | 2.55 per cent. |
| Phosphoric acid, | 10.26 " |
| Potash, | 3.15 " |

Price, $40 in Boston. Chemical value, $38.

### QUINNIPIAC PHOSPHATE.

| | |
|---|---|
| Nitrogen, | 3.30 per cent. |
| Phosphoric acid, | 10.50 " |
| Potash, | 3.00 " |

Price, $45 retail, $40 wholesale. Chemical value, $42.

### AMERICAN BRAND SUPERPHOSPHATE.

| | |
|---|---|
| Nitrogen, | 2.38 per cent. |
| Phosphoric acid, | 10.75 " |
| Potash, | 2.50 " |

Price, $40. Chemical value, $39.50.

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PACIFIC GUANO.

| | |
|---|---|
| Nitrogen, . . . . . | 2.65 per cent. |
| Phosphoric acid, . . . . . | 10.00 " |
| Potash, . . . . . | 3.75 " |

Price, $40. Chemical value, $39.50.

BOWKER'S HILL AND DRILL.

By Prof. Goessman, of Massachusetts:

| | | |
|---|---|---|
| Nitrogen, . . . . | 3.82 per cent. | Worth $39.36 |
| Phosphoric acid, total, . . | 12.85 " | |
| Potash, . . . . | 1.91 " | |

By Prof. Sabine, Vermont:

| | | |
|---|---|---|
| Nitrogen, . . . . | 3.08 per cent. | Worth $39.02 |
| Phosphoric acid, . . . | 13.19 " | |
| Potash, . . . . | 2.95 " | |

By Prof. Blanpied, New Hampshire:

| | | |
|---|---|---|
| Nitrogen, . . . . | 2.88 per cent. | Worth $38.69 |
| Phosphoric acid, . . . | 13.23 " | |
| Potash, . . . . | 1.77 " | |

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